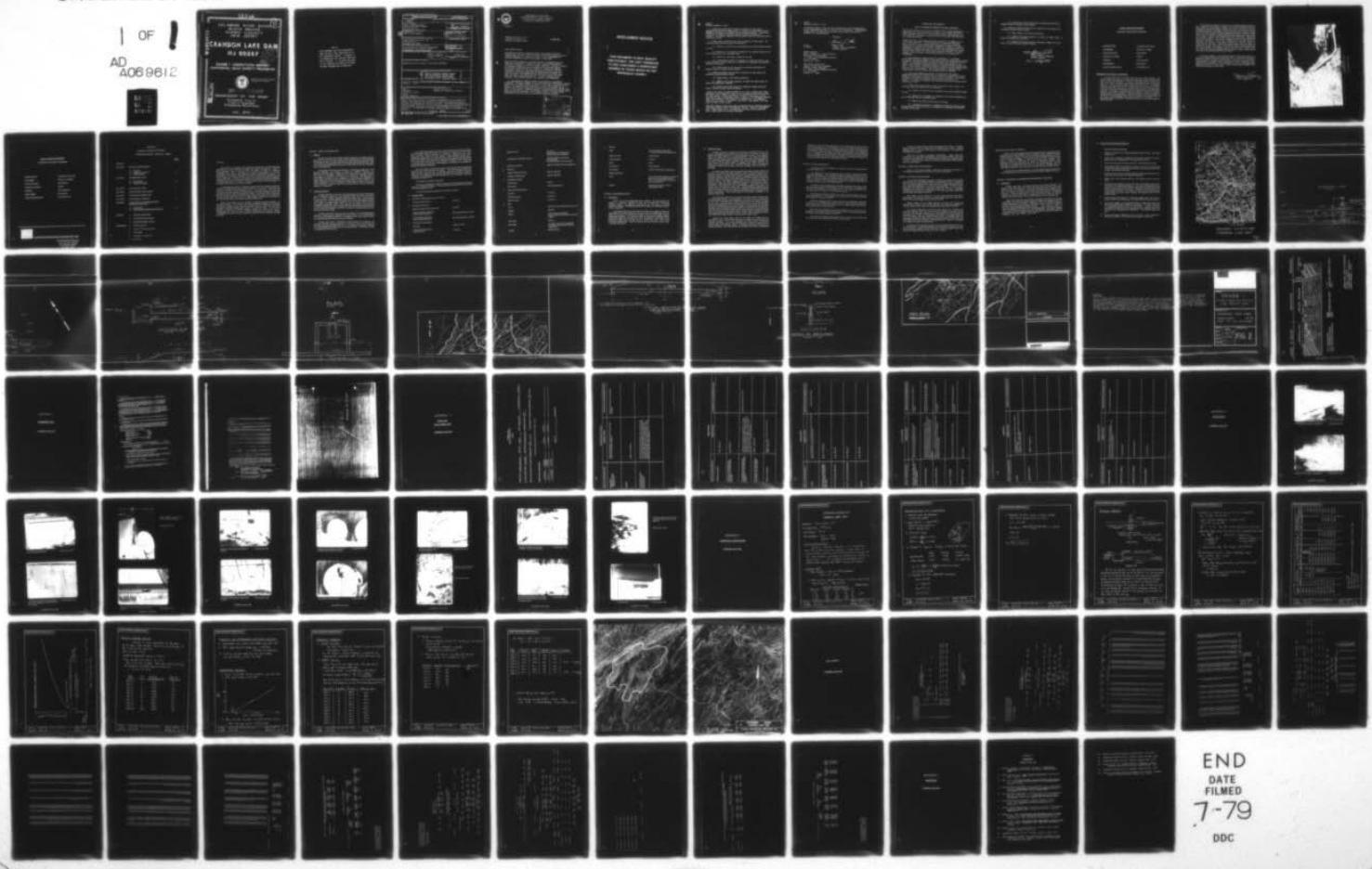


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NATIONAL DAM SAFETY PROGRAM. CRANDON LAKE DAM (NJ 00267), DELAW--ETC(U)  
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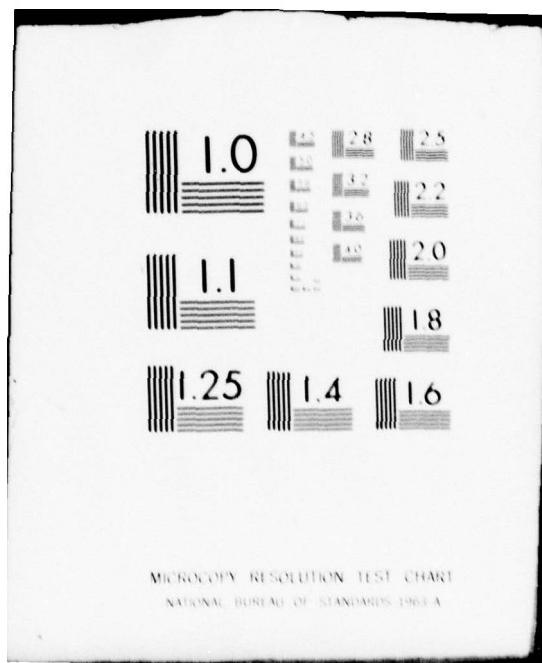
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DELAWARE RIVER BASIN  
BLACK BROOK  
SUSSEX COUNTY  
NEW JERSEY

# CRANDON LAKE DAM NJ 00267

PHASE 1 INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM



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DEPARTMENT OF THE ARMY

Philadelphia District  
Corps of Engineers  
Philadelphia, Pennsylvania

May, 1979

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER <b>NJ00267</b>	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Inspection Report National Dam Safety Program Crandon Lake Dam Sussex County, New Jersey	5. TYPE OF REPORT & PERIOD COVERED <b>(9) FINAL Rept.</b>	
7. AUTHOR(s) Dennis J. Leary, P.E.	6. PERFORMING ORG. REPORT NUMBER <b>(15) DACW61-78-C-0124</b>	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Langan Engineering Assoc. Inc. 970 Clifton Ave. Clifton, N.J. 07013	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, Philadelphia Custom House, 2d & Chestnut Streets Philadelphia, Pennsylvania 19106	12. REPORT DATE <b>(11) May 9 1979</b>	
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18. SUPPLEMENTARY NOTES  Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dams Spillways Structural Analysis Safety Visual inspection	Crandon Lake Dam, N.J. National Dam Inspection Act Report	
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.	440 894	

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PHILADELPHIA DISTRICT, CORPS OF ENGINEERS  
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PHILADELPHIA, PENNSYLVANIA 19106**

IN REPLY REFER TO  
NAPEN-D

Honorable Brendan T. Byrne  
Governor of New Jersey  
Trenton, New Jersey 08621

17 MAY 1979

**Dear Governor Byrne:**

Inclosed is the Phase I Inspection Report for Crandon Lake Dam in Sussex County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Crandon Lake Dam, a high hazard potential structure, is judged to be in fair overall condition. The dam's spillway is considered inadequate since 21 percent of the Probable Maximum Flood would overtop the dam. The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the fact that failure from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

- a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980. In the interim, a detailed emergency operation plan and warning system, should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

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NAPEN-D

Honorable Brendan T. Byrne

b. Within six months from the date of approval of this report, engineering studies and analyses should be initiated to determine the dam's embankment and foundation condition and structural stability. This should include test borings to determine material properties relative to stability. Any remedial measures found necessary should be initiated within calendar year 1980.

c. Within three months from the date of approval of this report, the following remedial actions should be completed:

(1) Replace or reline the two corrugated metal pipes passing through the dam.

(2) Repair and, if necessary, strengthen the concrete headwalls for the box spillway and the discharge pipes.

(3) Remove all trees from the area of the dam.

(4) Investigations should be conducted to locate the inlet of the 36-inch diameter blow-off pipe and to determine the existence and operating condition of its gate.

(5) Eroded areas of the dam should be suitably backfilled and measures taken to prevent future erosion.

d. Within six months from the date of approval of this report the following actions should be taken:

(1) Repair leaks in the drop-box spillway.

(2) Operate sluice gate regularly, at least two times a year, to ensure its operational condition.

(3) Animal burrow holes should be completely plugged and steps taken to prevent further animal burrowing.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman James A. Courter of the Thirteenth District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

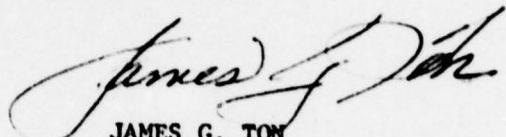
Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

NAPEN-D

Honorable Brendan T. Byrne

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,



1 Incl  
As stated

JAMES G. TON  
Colonel, Corps of Engineers  
District Engineer

Copies furnished:

Dirk C. Hofman, P.E., Deputy Director  
Division of Water Resources  
N. J. Dept. of Environmental Protection  
P. O. Box CN029  
Trenton, NJ 08625

John O'Dowd, Acting Chief  
Bureau of Flood Plain Management  
Division of Water Resources  
N. J. Dept. of Environmental Protection  
P. O. Box CN029  
Trenton, NJ 08625

CRANDON LAKE DAM (NJ00267)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 13 and 20 December 1978 by Langan Engineering Associates, Inc. under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Crandon Lake Dam, a high hazard potential structure, is judged to be in fair overall condition. The dam's spillway is considered inadequate since 21 percent of the Probable Maximum Flood would overtop the dam. The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the fact that failure from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980. In the interim, a detailed emergency operation plan and warning system, should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

b. Within six months from the date of approval of this report, engineering studies and analyses should be initiated to determine the dam's embankment and foundation condition and structural stability. This should include test borings to determine material properties relative to stability. Any remedial measures found necessary should be initiated within calendar year 1980.

c. Within three months from the date of approval of this report, the following remedial actions should be completed:

(1) Replace or reline the two corrugated metal pipes passing through the dam.

(2) Repair and, if necessary, strengthen the concrete headwalls for the box spillway and the discharge pipes.

(3) Remove all trees from the area of the dam.

(4) Investigations should be conducted to locate the inlet of the 36-inch diameter blow-off pipe and to determine the existence and operating condition of its gate.

(5) Eroded areas of the dam should be suitably backfilled and measures taken to prevent future erosion.

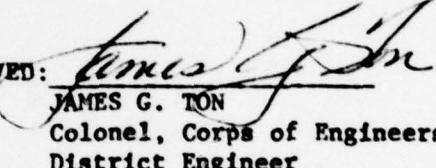
d. Within six months from the date of approval of this report the following actions should be taken:

(1) Repair leaks in the drop-box spillway.

(2) Operate sluice gate regularly, at least two times a year, to ensure its operational condition.

(3) Animal burrow holes should be completely plugged and steps taken to prevent further animal burrowing.

APPROVED:

  
JAMES G. TON  
Colonel, Corps of Engineers  
District Engineer

DATE: 17 May 1929

**PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM**

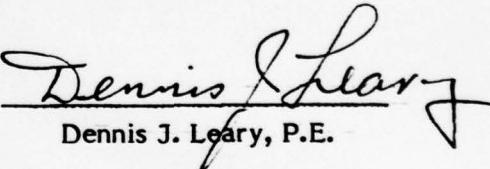
<b>NAME OF DAM:</b>	<b>CRANDON LAKE DAM</b>
<b>ID NUMBER:</b>	<b>FED ID No NJ00267</b>
<b>STATE LOCATED:</b>	<b>NEW JERSEY</b>
<b>COUNTY LOCATED:</b>	<b>SUSSEX</b>
<b>STREAM:</b>	<b>BLACK BROOK</b>
<b>RIVER BASIN:</b>	<b>DELAWARE</b>
<b>DATE OF INSPECTION:</b>	<b>DECEMBER 1978</b>

**ASSESSMENT OF GENERAL CONDITIONS**

Crandon Lake Dam is 20 years old and in fair overall condition. The spillway outlet pipes and the low level outlet pipe have rusted over the lower portion of their circumference. There are trees growing on the slopes of the dam. Erosion has occurred on the slopes of the dam and near the spillway structure. There are animal holes in the downstream slope. The drop-box headwall has cracked and water is seeping into the left corner of the box. There are numerous cracks on the concrete headwall for the discharge pipes. Only little information concerning the design and construction of the dam is available. No records of material quality or degree of compaction achieved during construction are available. The maximum depth to which the subsurface conditions were investigated before construction appears to have been about four feet, this is also unacceptable. The spillway capacity as determined by CE Screening criteria is inadequate. We estimate the dam can adequately pass only 20% of the PMF.

We recommend to replace or reline the two CM pipes passing through the dam. Repair and, if necessary, strengthen the concrete headwalls for the box spillway and the discharge pipes. Remove all trees from the area of the dam. Investigation should be conducted to locate the inlet of the 36in-dia blow-off pipe and to determine the existence and operating condition of its gate. Eroded areas of the dam should be suitably backfilled and measures taken to prevent future erosion. The above recommendations should be done soon. Repair leaks in the drop-box spillway. This should be done in the near future. Borings and tests should be made in the dam and foundation materials to determine their engineering properties. The actual configuration of the dam section, in particular the upstream slope below normal pool elevation, should be determined by field survey. Analyses should be made of the actual degree of stability of the dam with respect to conventional safety margins under static and seismic loading. This should be done in the near future. Animal burrow hole should be completely plugged and steps taken to prevent further animal burrowing. This should be done in the near future.

The actual capacity of the spillway should be determined using more precise and sophisticated methods and procedures. The need for and type of mitigating measures should be determined. Around the clock surveillance during periods of unusually heavy precipitation should be provided, and a warning system established. This should be done very soon. Operate sluice gate regularly, at least two times a year to ensure its operational condition. This should be done regularly in the future.

  
Dennis J. Leary  
Dennis J. Leary, P.E.



OVERVIEW  
CRANDON LAKE DAM

13 December 1978

**PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM**

**NAME OF DAM:** CRANDON LAKE DAM  
**ID NUMBER:** FED ID No NJ00267  
**STATE LOCATED:** NEW JERSEY  
**COUNTY LOCATED:** SUSSEX  
**STREAM:** BLACK BROOK  
**RIVER BASIN:** DELAWARE  
**DATE OF INSPECTION:** DECEMBER 1978



**LANGAN ENGINEERING ASSOCIATES, INC.**

**Consulting Civil Engineers  
990 CLIFTON AVENUE  
CLIFTON, NEW JERSEY  
201-472-9366**

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CRANDON LAKE DAM FED ID No. NJ00267

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## PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

## SECTION I PROJECT INFORMATION

### 1.1 General

Authority to perform the Phase I Safety Inspection of Crandon Lake Dam was received from the State of New Jersey, Department of Environmental Protection, Division of Water Resources by letter dated 20 November 1978. This Authority was given pursuant to the National Dam Inspection Act, Public Law 92-367 and by agreement between the State and the US Army Engineers District, Philadelphia.

The purpose of the Phase I Investigation is to develop an assessment of the general conditions with respect to safety of Crandon Lake Dam and appurtenances based upon available data and visual inspection, and, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted. The assessment is made using screening criteria established in Recommended Guidelines for Safety Inspection of Dams prepared by the Department of Army, Office of the Chief of Engineers. It is not the purpose of the inspection report to imply that a dam meeting or failing to meet the screening criteria, is per se, certainly adequate or inadequate.

### 1.2 Project Description

Crandon Lake Dam is a 20 year old, 428-ft-long, 20-ft-high, earthfill dam with a compacted central core. It is reported that the dam has a top width of 28 ft, a 2H:1V partially riprapped upstream slope, and a 3H:1V grassed downstream slope. Visual inspection shows the upstream slope above lake level is about 5H: 1V. It has a drop box spillway with a total weir length of 49 feet. The spillway discharge passes under the dam by means of two 6-ft-dia corrugated metal pipes. There are provisions for stop planks in the north face of the box spillway and there is a gated 3-ft-dia CM low level outlet pipe about 40 feet west of the spillway. The top of the dam is an asphalt paved roadway that also encircles the lake.

The dam is located at the south end of Crandon Lake on the Hampton and Stillwater Township line in Sussex County, New Jersey. It is at north latitude 41° 7.6' and west longitude 74° 50.5'. A regional vicinity map is given in Fig 1 and essential features of the dam are given in Fig 2.

Crandon Lake Dam is classified as being "Small" on the basis of its maximum reservoir storage volume of 510 acre-feet, which is more than 50-acre feet, but less than 1,000-acre feet. It is classified as "Small" on the basis of its total height of 20 feet, which is less than 40 feet. Accordingly, the dam is classified as "Small" in size.

In the National Inventory of Dams, Crandon Lake Dam has been classified as having "High Hazard Potential" on the basis that failure of the dam would cause excessive property damage to residences downstream, and could potentially cause more than a few deaths. Visual inspection shows that a smaller lake locates about 1/4 mile downstream from the dam and that breach of the dam would be very hazardous to people utilizing Benevolence Road on top of the dam and would cause excess damage and hazard to the residences situated abutting the lower lake. Accordingly, it is proposed not to change the Hazard Classification Potential.

The dam is known to have been owned by the Crandon Lakes Development Company, Inc., RD #3, Newton, New Jersey. The information provided by the State indicates that the dam is presently owned by Stillwater Township. However, from a telephone conversation with Mdm. Ellen Vanstone of Stillwater Township, it is understood that the Township does not own the dam. Its present ownership is unknown to us.

The purpose of the dam is recreation.

The dam was designed by Waldo J. Clarke, Professional Engineer and Land Surveyor, Franklin, New Jersey. Construction work was started in 1957 and the dam was completed in 1959.

No normal operational procedures are known to be used.

**1.3 Pertinent Data**

- a. At dam site, the drainage area is 2.45 sq mi

The area of the Lake is: 70 Acres +

- b. Discharge at Dam Site

Maximum known flood at dam site: Unknown

Ungated spillway capacity at maximum pool elevation: 840 cfs (governed by culvert)

Total spillway capacity at maximum pool elevation: 840 cfs (governed by culvert)

- c. Elevation (ft above MSL)

Top dam: Approx. El. 859

Normal pool (assumed at spillway crest): El. 855.3

Spillway crest:	El. 855.3 (Stop plank crest elevation at 854.44 at time of inspection)
Streambed at centerline of dam:	El. 843.4 (invert of 36-in-dia blow-off pipe) El. 845.3 (invert of 6-ft-dia CMP)
Maximum tailwater:	Approx. El. 846 at time of inspection.
d. Reservoir	
Length of Maximum pool:	Approx. 4025 feet
Length of normal pool:	Approx. 4000 feet
e. Storage (acre-feet)	
Normal pool:	230 AF
Top of dam:	510 AF (estimated)
f. Reservoir Surface (acres)	
Top dam:	74 Acres <u>±</u>
Recreation pool:	70 Acres <u>±</u>
Spillway crest:	70 Acres <u>±</u>
g. Dam	
Type:	Earth fill with compacted central core
Length:	428 feet
Height:	16 feet (above streambed) 20 feet (estimated maximum structural height)
Top width:	28 feet <u>±</u>
Side slopes:	U/S 3H:1V; D/S 3H:1V (reported) U/S above lake level 5H:1V (visual inspection)
Zoning:	None observed

<b>h. Spillway</b>	
Type:	Concrete drop box feeds into 2 - 6-ft-dia CMP under embankment.
Length of weir:	49 feet, total
Crest elevation:	EI. 855.3
Gates:	None
U/S channel:	None observed
D/S channel:	2-6-ft-dia CMP under embankment.
<b>i. Regulating Outlets</b>	
Type:	36-in-dia blow-off pipe with underwater gate at west side of spillway box and 3" x 8" stop planks in north face of the spillway box.
Length:	Blow-off pipe approx. 92 feet Stop planks 3 feet.

## SECTION 2 ENGINEERING DATA

### 2.1 Introduction

There is very little engineering data available. The specification and records of inspection indicate the dam was satisfactorily constructed. However, there is no quantitative information e.g. test results or testing frequency available. Available geotechnical, hydraulic, and hydrologic data are given in Appendix 1.

It is reported that in the early phase of construction, compaction was done using rubber tired earth movers. In our opinion that is unsatisfactory and it is likely that both the core and shell sections of the dam have highly variable engineering properties. The maximum depth of subsurface exploration before construction appears to be about 4-ft which corresponds to the bottom of the exploration trench that was dug along the base of the dam. This is also considered unsatisfactory. There is insufficient information upon which to make a complete evaluation.

## 2.2 Regional Geology

Crandon Lake Dam is located in the Valley and Ridge Province. This province encompasses one-twelfth of the land area of the state - chiefly in Warren and Sussex Counties. It is characterized by a series of nearly parallel ridges and valleys that trend northeast-southwest. The ridges are underlain with northwest dipping Silurian and Devonian sandstones and conglomerates. The upper Delaware Valley is underlain with weak Devonian limestones and shales while the Kittatinny Valley is underlain with folded Cambrian and Ordovician limestones and shales. Kittatinny Mountain is the most prominent topographic feature and its nearly even crest averages 1600 to 1800 feet in elevation.

The Valley and Ridge Province is divided into western, middle, and eastern sections that include the Upper Delaware Valley, Kittatinny Mountain, and Kittatinny Valley. The Upper Delaware Valley encompasses the region west of Kittatinny Mountain that has been eroded in Devonian limestones and shales. Kittatinny Mountain makes up the middle section of the Province and forms the eastern border of the Upper Delaware Valley and the northwestern border of Kittatinny Valley. The ridge is underlain with the very resistant lower Silurian Shawangunk conglomerate and High Falls sandstone. The northeastern side is bordered by the escarpments of the Shawangunk conglomerate, which rise steeply from the Kittatinny Valley floor. The Shawangunk conglomerate has been extensively broken up into large rock fragments by mechanical weathering and frost action and forms mass wasted talus slopes along the ramparts of the eastern escarpment. These talus slopes are extensively developed in the Delaware Water Gap.

The Kittatinny Valley area is a broad northeast-southwest lowland where the Harrisburg Peneplain is well developed. The valley is 10 to 13 miles wide and lies between the New Jersey Highlands on the east and Kittatinny Mountain on the west. The Wisconsin ice sheet covered all of the Valley and Ridge Province and deposited a terminal moraine south of the province near Belvidere. Much of the land surface north of the terminal moraine consists of a thin sheet of glacial till and ice-scoured bedrock surfaces. In addition, fluvial deposits of stratified drift consisting of eskers, kames, kame terraces, and deltas mantle many of the areas of the valley bottoms. Discontinuous recessional moraines were deposited during stillstands in the ice retreat. These moraines now form a discontinuous low band of hills across nearly all of Sussex County.

Glacial till covers large areas of the Valley and Ridge Province. Generally the till is extremely thin and sometimes present only in patches or as scattered boulders. It is best developed on broad summits, interstream surfaces, and in low passes or cols, and is thinnest or absent on steep slopes, on narrow ridges, and in narrow valleys. The greatest thickness of the till in the Kittatinny Valley is over 100 feet just on the edge of the valley at Ogdensburg.

Estimates of the thickness range from 8 to 10 feet along the west slope of Kittatinny Mountain; 2 to 3 feet along the crest of Kittatinny Mountain; 5 to 10 feet on the limestone belts of Kittatinny Valley; 8 to 12 feet on the shale belts of Kittatinny Valley; and from 5 to 20 feet in Vernon Valley. The composition of till is largely of local origin and reflects the character of the underlying rock. It is generally compact because of the high clay content derived from the weathered shales and has many resistant boulders of Shawangunk conglomerate as well as erratics derived from more distant sources.

### SECTION 3 VISUAL INSPECTION

The general overall conditions of Crandon Lake Dam and appurtenant structures appear fair.

The alignment of the embankment and its junction with the abutments appeared satisfactory. No noticeable seepage or leakage was observed. Both slopes of the embankment are overgrown with small to medium size trees and bushes. Erosion was observed along the sides of the downstream headwalls for the outlet conduits. Some erosion was also observed on upstream slope near the drop-box structure and at a few other locations.

At the time of our inspection, the lake was partially frozen and the water level was approximately 2 inches below the top of the spillway. Drainage out of the lake was maintained by removing some of the stop-logs placed in the vertical slot on the north face of the drop-box spillway.

The drop-box spillway structure has a few localized spalled areas and surface deterioration. Small seepage was observed at the left corner abutting the headwall for the outlet conduits.

There are numerous cracks on both upstream and downstream headwalls for the two 6-ft-dia CMP outlet conduits which run across the base of the dam. These cracks vary in width from hairline to 1 inch. Some of them extend across the exposed surfaces of the structure.

There are minor spalling on the outlet headwall for the 3-ft-dia low level CM pipe. A metal drum lies across its outlet channel. No inlet structure was observed for this conduit during our inspection.

The two 6-ft-dia spillway outlet pipes and the 3-ft-dia low level outlet pipe have rusted over the lower portion of their circumferences.

There are numerous homes around the perimeter of the lake. The slopes appear relatively flat and stable with occasional minor erosion. Vertical bulkheads exist in front of some homes at the waterfront. No significant sedimentation was noted.

There are no homes immediately downstream. About 1000 feet downstream is a lower lake surrounded by numerous scattered homes with a few at relatively low elevation. The lower lake has a surface area of approximately 10 acres. The downstream channel was partially obstructed by fallen leaves, trees and wood boards.

#### SECTION 4 OPERATIONAL PROCEDURES

There is no readily available information concerning operational or maintenance procedures or the existence of any working system.

#### SECTION 5 HYDRAULIC/HYDROLOGIC

The hydraulic/hydrologic evaluation is based on a Spillway Design Flood (SDF) equal to the full Probable Maximum Flood (PMF) chosen in accordance with the evaluation guidelines for dams classified as High Hazard and Small in size. Hydrologic design data for this dam is not available. The PMF has been determined by developing a synthetic hydrograph based on the maximum probable precipitation of 22 inches (200 square mile - 24 hour). Hydrologic computations are presented in Appendix 4. The PMF peak inflow determined for the subject watershed is 7,807 cfs.

The capacity of the spillway at maximum pool elevation (El. 859) is governed by the capacity of the two 6-ft-dia CMP under the embankment, which is 840 cfs and is significantly less than the SDF.

Flood routing for the PMF indicates the dam will overtop by approximately 3.2 feet. For 1/2 PMF the same will overtop by approximately 1.7 feet. We estimate the dam can adequately pass only 20% of the PMF.

The nearest downstream potential damage centers are a roadway and residential dwellings which are situated abutting a small lake located 1/4 mile to a mile from the dam. Based on our visual inspection of the downstream topography, and the dam and knowledge of the degree of overtopping potential it is our opinion that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. However, overtopping by 1/2 PMF is not likely to cause failure.

Drawdown of the reservoir has been evaluated considering that the 36 in-dia blow-off pipe is functioning properly and is utilized for lowering the lake. Our calculations indicate that the lake level could be lowered 3 feet from spillway crest approximately 1 day and 6 ft in 1 1/2 days.

## SECTION 6 STRUCTURAL STABILITY

Based on our visual inspection, the dam appears stable. The geometry and dimensions of the dam together with our review of the available records also indicate the dam is stable. There are no available operating records or records of post construction changes. It is our opinion that the dam is presently stable and it is likely its stability is within conventional safety margins. This likelihood should be confirmed by means of appropriate analyses using representative engineering properties of the dam and foundation. We are particularly concerned with the cracks in the spillway headwall and the continued rusting of the invert portions of the pipes that pass through the dam.

Because there is inadequate data concerning engineering properties of the materials used in the dam it is uncertain as to the seismic stability of the dam.

## SECTION 7 ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

### 7.1 Assessment

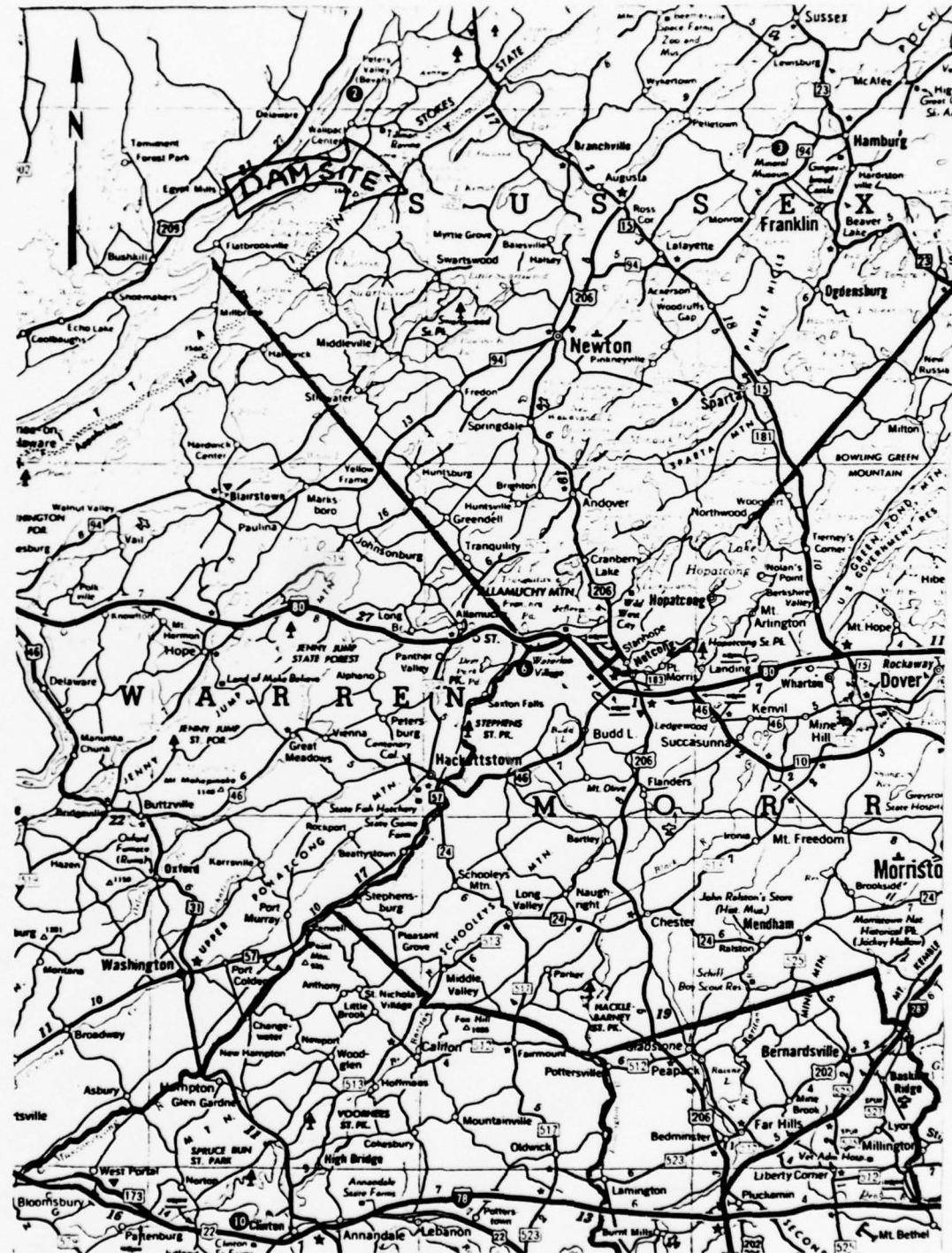
Crandon Lake Dam is 20 years old and in fair overall condition. The spillway outlet pipes and the low level outlet pipe have rusted over the lower portion of their circumference. There are trees growing on the slopes of the dam. Erosion has occurred on the slopes of the dam and near the spillway structure. There are animal holes in the downstream slope. The drop-box headwall has cracked and water is seeping into the left corner of the box. There are numerous cracks on the concrete headwall for the discharge pipes.

Only little information concerning the design and construction of the dam is available. No records of material quality or degree of compaction achieved during construction are available. Compaction of the core and shell sections of the dam involved the use of rubber tired earth movers to achieve compaction which is not an acceptable present day method. The maximum depth to which the subsurface conditions were investigated before construction appears to have been about four feet, this is also unacceptable. The spillway capacity as determined by CE screening criteria is inadequate. We estimate the dam can adequately pass only 20% of the PMF.

## **7.2 Recommendations/Remedial Measures**

We recommend the following:

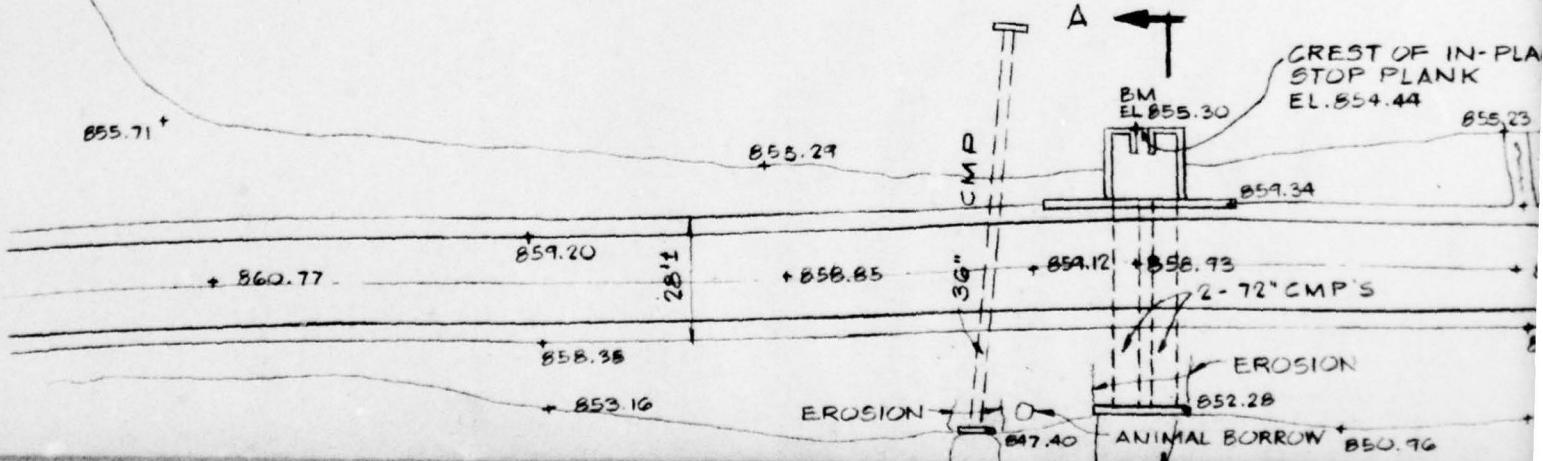
1. Replace or reline the two CM pipes passing through the dam. This should be done soon.
2. Repair and, if necessary, strengthen the concrete headwalls for the box spillway and the discharge pipes. This should be done soon.
3. Remove all trees from the area of the dam. This should be done soon.
4. Investigation should be conducted to locate the inlet of the 36-in-dia blow-off pipe and to determine the existence and operating condition of its gate. This should be done soon.
5. Eroded areas of the dam should be suitably backfilled and measures taken to prevent future erosion. This should be done soon.
6. Repair leaks in the drop-box spillway. This should be done in the near future.
7. Borings and tests should be made in the dam and foundation materials to determine their engineering properties. The actual configuration of the dam section, in particular the upstream slope below normal pool elevation, should be determined by field survey. Analyses should be made of the actual degree of stability of the dam with respect to conventional safety margins under static and seismic loading. This should be done in the near future.
8. Animal burrow holes should be completely plugged and steps taken to prevent further animal burrowing. This should be done in the near future.
9. The actual capacity of the spillway should be determined using more precise and sophisticated methods and procedures. The need for and type of mitigating measures should be determined. Around the clock surveillance during periods of unusually heavy precipitation should be provided, and a warning system established. This should be done very soon.
10. Operate sluice gate regularly, at least two times a year, to ensure its operational condition. This should be done regularly in the future.



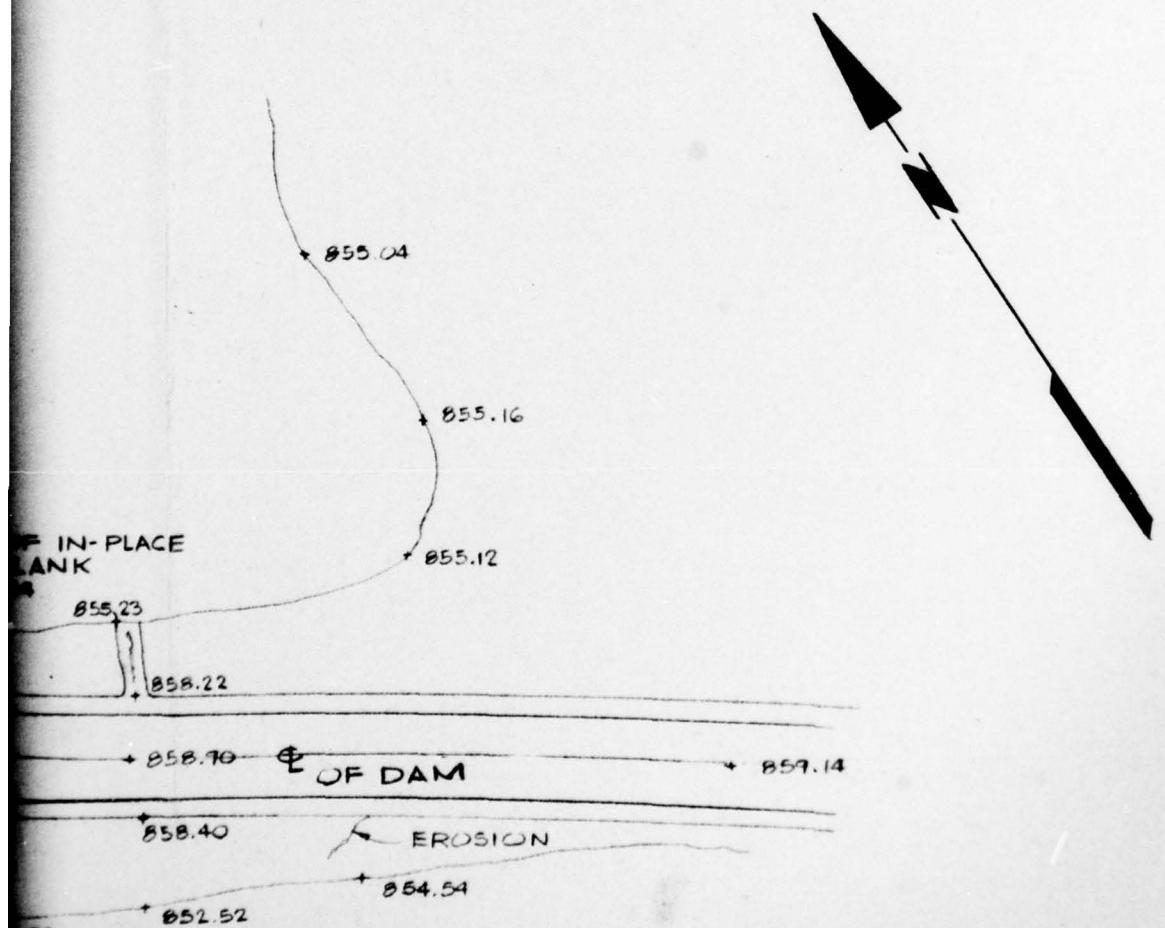
REGIONAL VICINITY MAP  
CRANDON LAKE DAM

Fig. 1

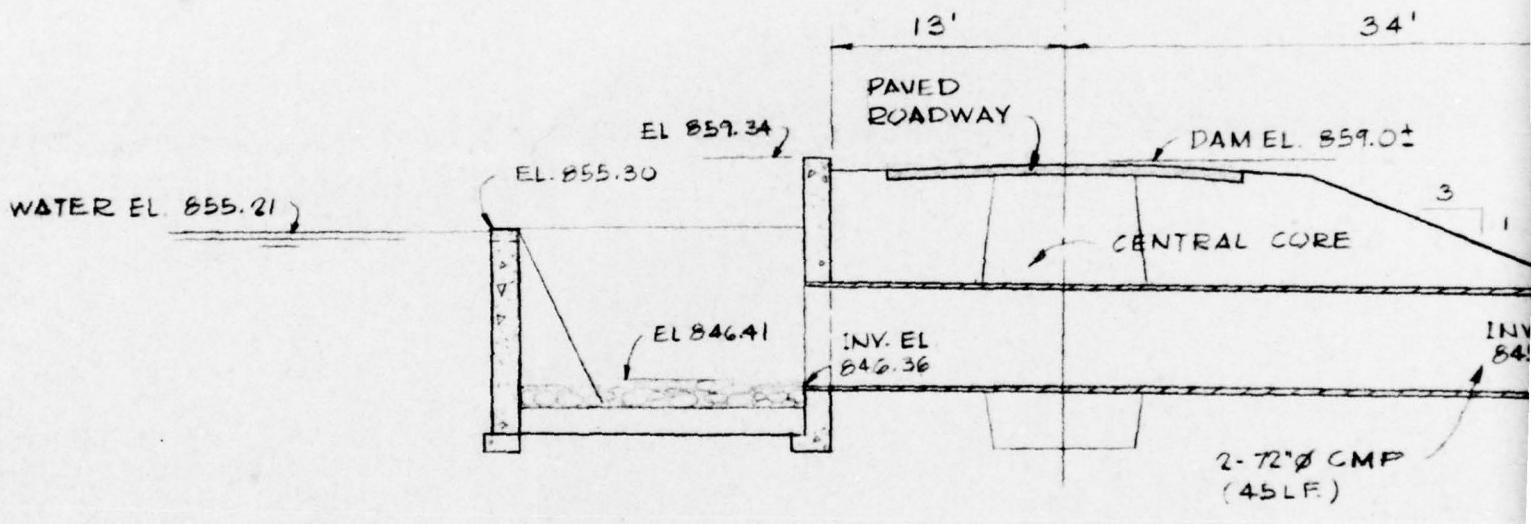
CRANDON LAKE  
EL. 855.21



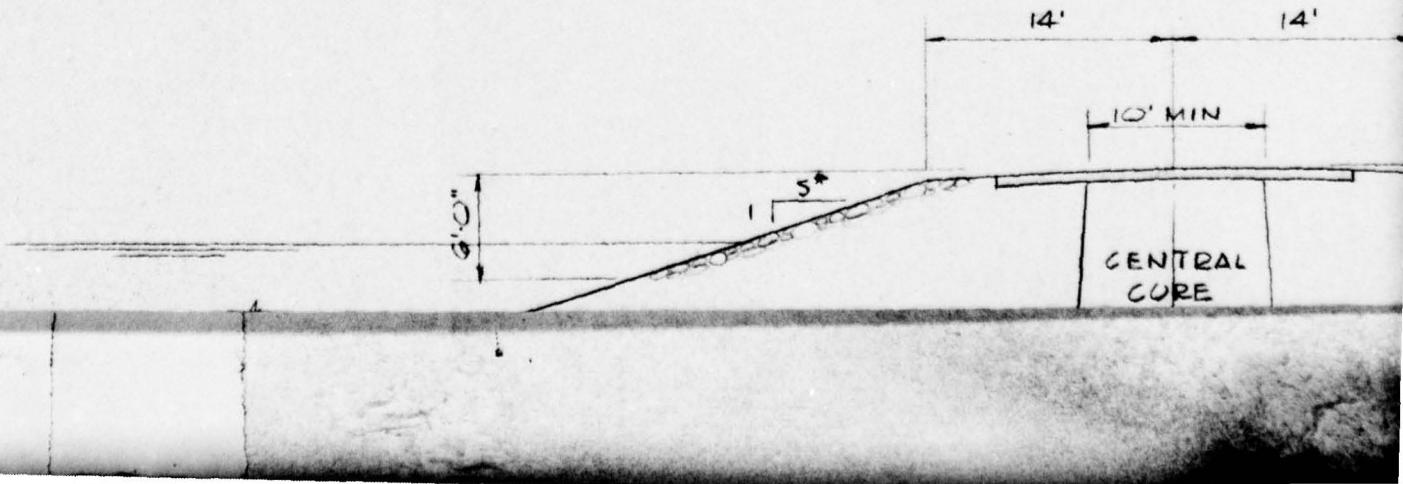
2



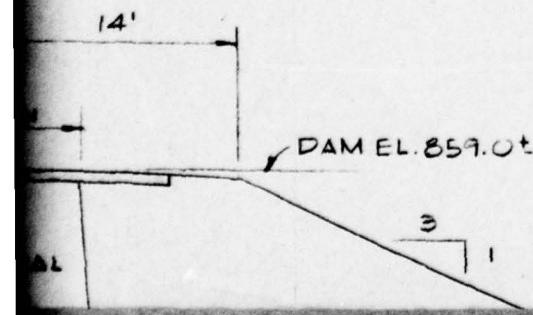
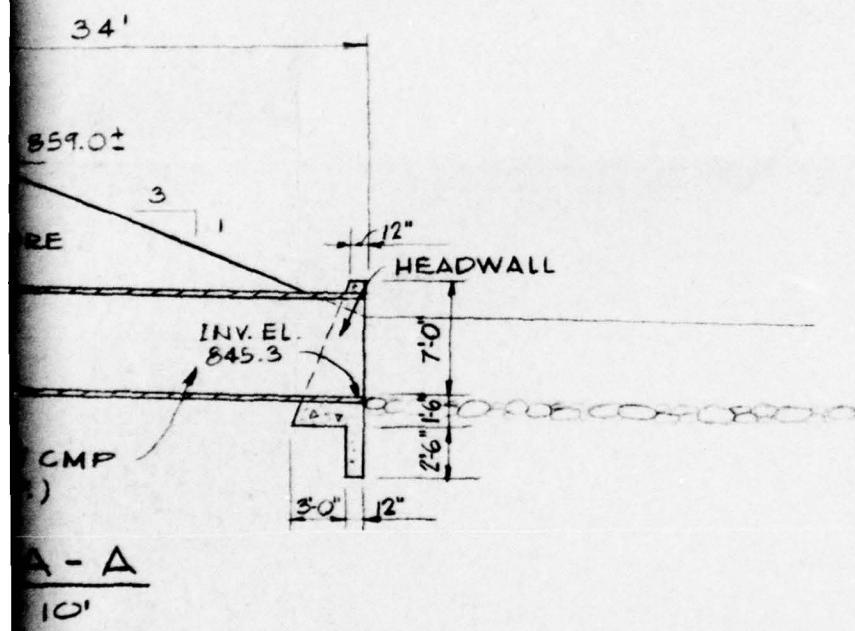
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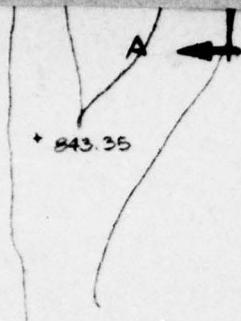


SECTION A-A  
SCALE: 1" = 10'

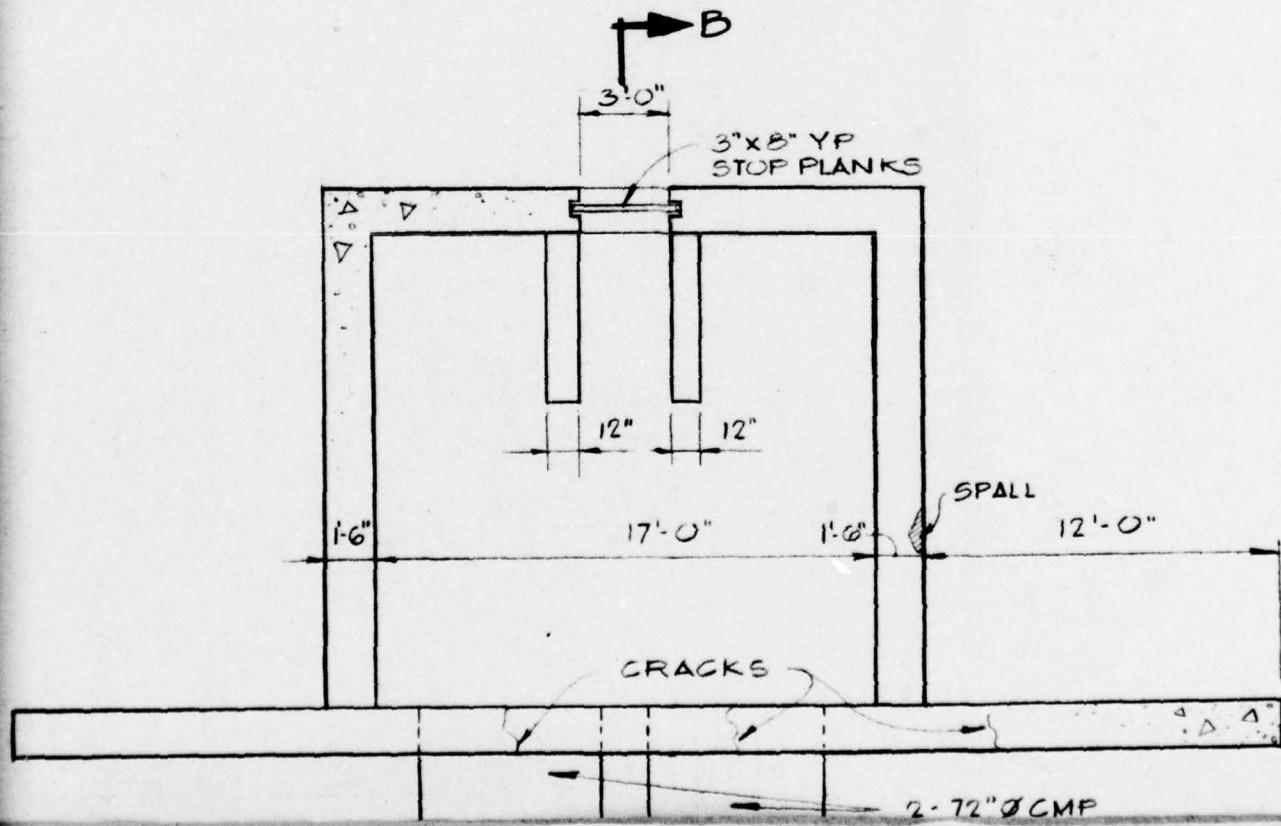


4

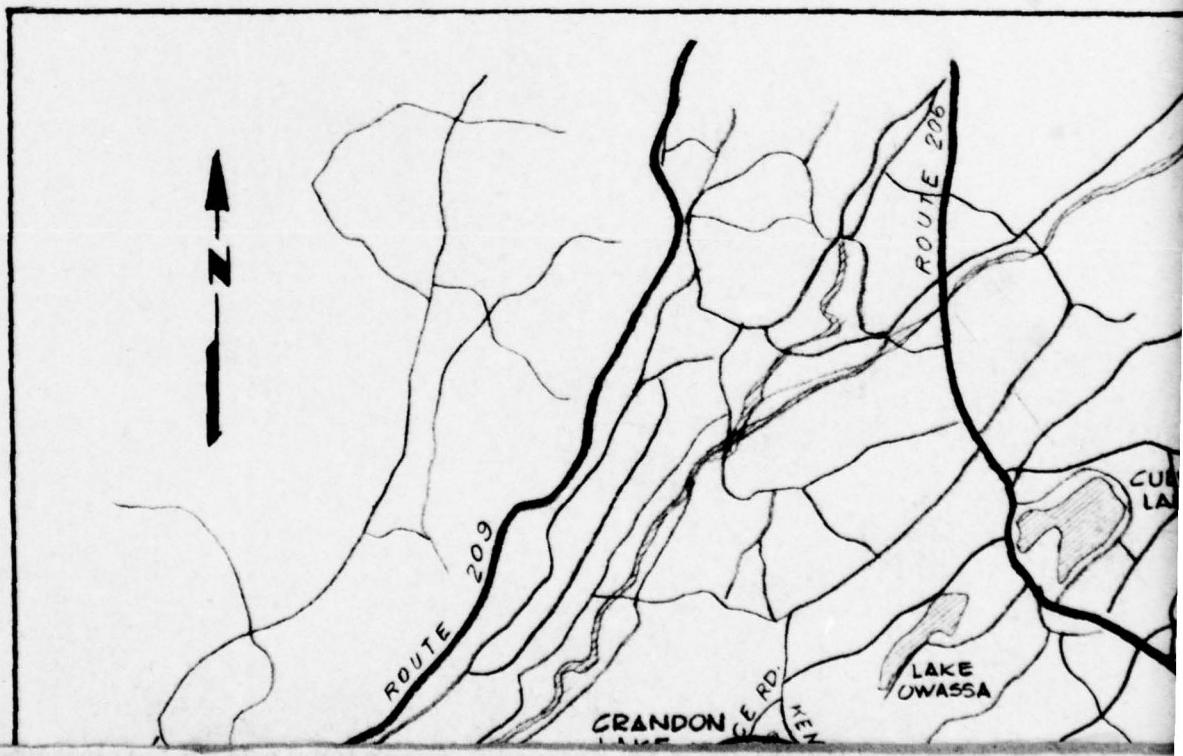




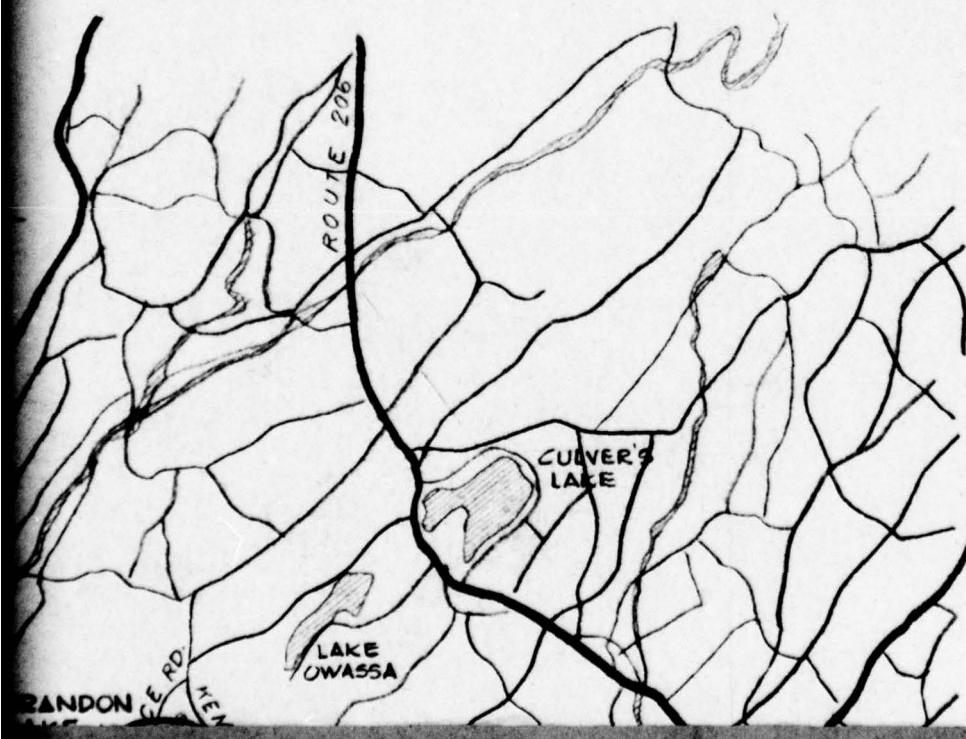
PLAN  
SCALE: 1"=40'

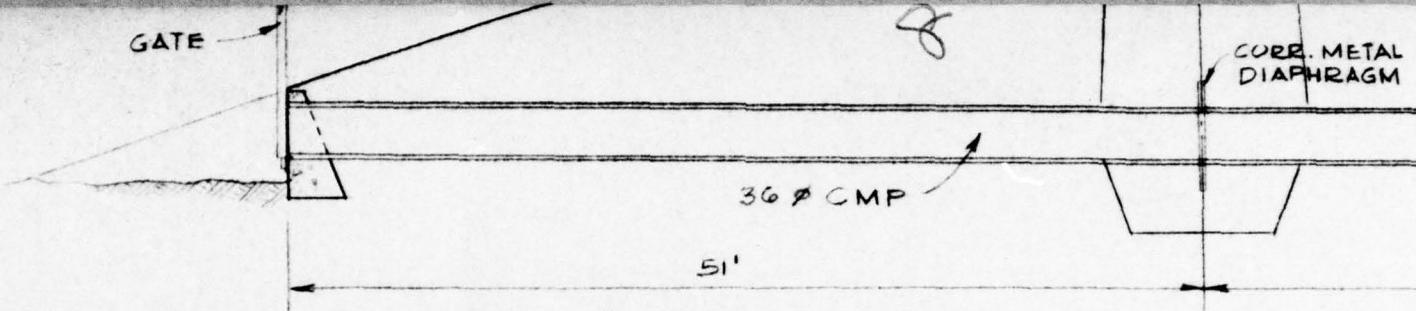


6



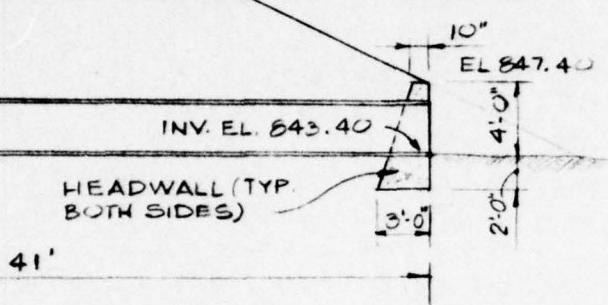
7





\* It is reported that the upstream slope of the embankment is 2H:1V  
Visual inspection shows the upstream slope above lake level is about 5H:1V

TYPICAL SECTION OF  
THRU BLOW-OFF PIPE  
SCALE 1" = 10'



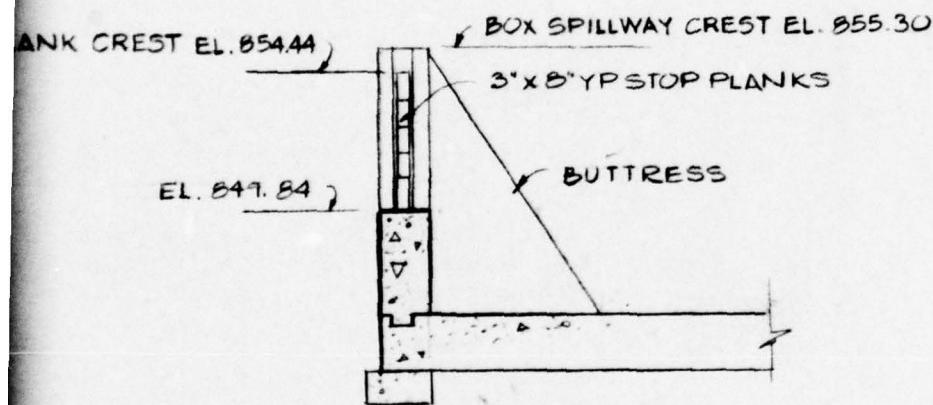
J OF DAM  
IPE

STOP PLANK CREST

DET



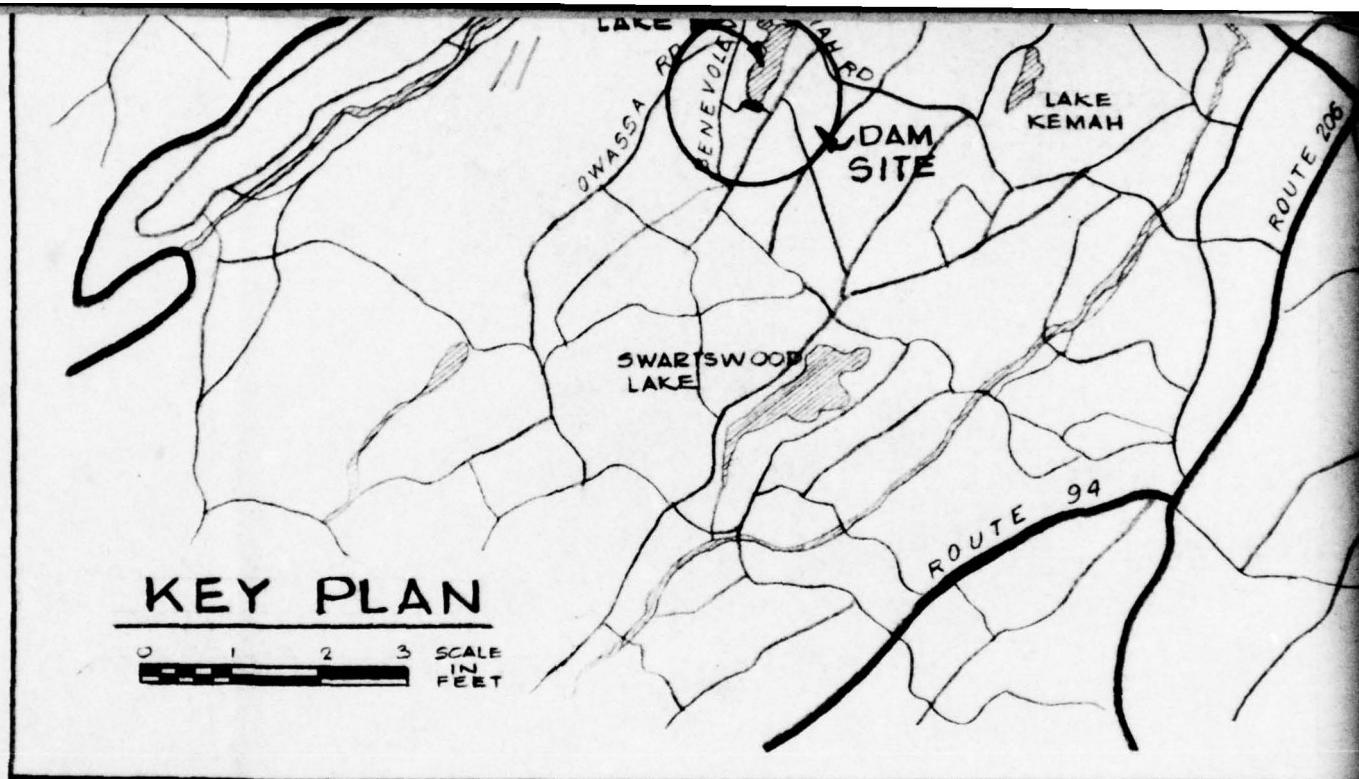
## PLAN

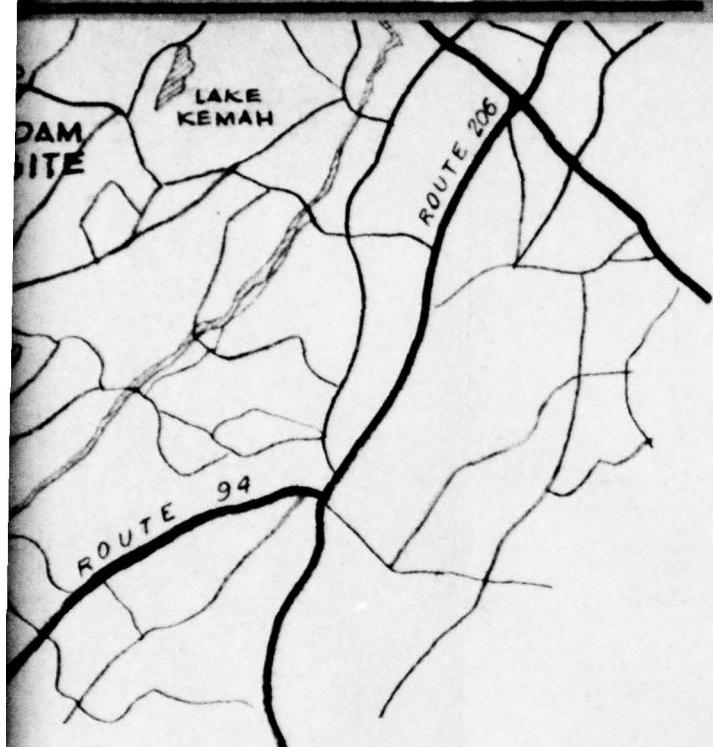


## SECTION B-B

### DETAIL OF SPILLWAY

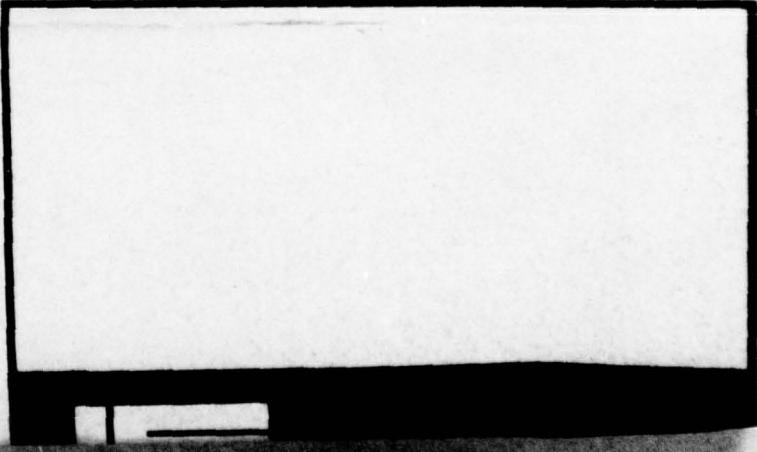
SCALE: 1" = 6'





12

DATE	DESCRIPTION	NO.
REVISIONS		



13

NOTE:

THE ELEVATIONS SHOWN WERE OBTAINED USING A SURVEYOR'S TRANSIT AND LEVEL. THE BENCHMARK ELEVATION OF 855.30 ON THE WALL OF THE SPILLWAY WAS USED AS WAS INDICATED ON THE DRAWINGS ENTITLED "CRANDON LAKE DAM, CRANDON LAKES DEV. CO. INC. HAMPTON STILLWATER TWPS. - SUSSEX CO. JUNE 1957, WALDO J CLARKE, P.E. FRANKLIN, N.J. THESE ELEVATIONS ARE APPROXIMATE. INFORMATION SHOWN BELOW GROUND SURFACE AND WATER LEVEL ARE INFERRED ON THE BASIS OF THE ABOVE MENTIONED DWGS.

14



INED USING A SURVEYOR'S  
N OF 855.30 ON THE WALL  
ON THE DRAWINGS  
DEV. CO. INC. HAMPTON  
VALDO J CLARKE, P.E.  
PROXIMATE INFORMATION  
LEVEL ARE INFERRED  
65.

PROJECT

PHASE I  
INSPECTION & EVALUATION  
OF  
NEW JERSEY DAMS

DRAWING TITLE

CRANDON LAKE DAM

FEBRUARY 1979  
FED. I.D. NO. NJ00267

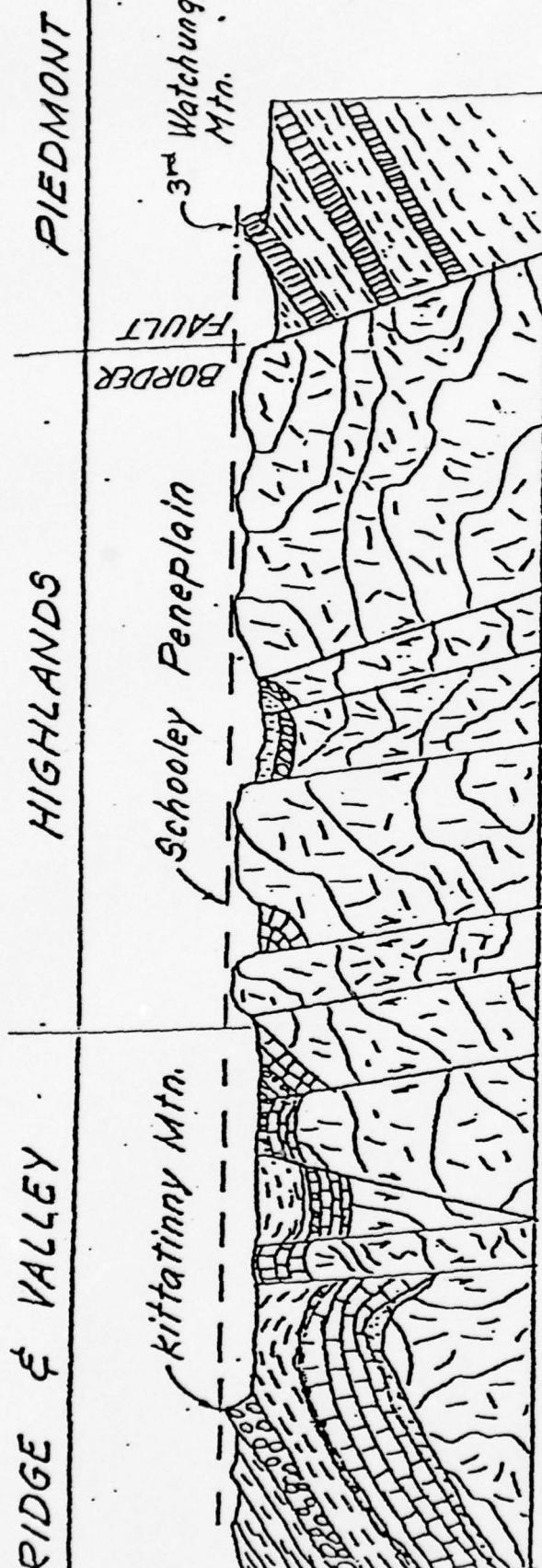
JOB NO.	DRAWING NO.
J - 783B	
DATE	
5 FEB 1979	
SCALE	
AS NOTED	
DRN. BY	
J. R.	
CHKD. BY	
D. J. L.	

FIG 2

## RIDGE & VALLEY

HIGHLANDS

PIEDMONT



## REGIONAL GEOLOGIC FEATURES

Fig. 3

Pre cambrian  
gneisses, schists  
and meta sediments

三

### Lava (Bassalt) floors

Schematic Cross-section of  
Ridge & Valley  
Physiographic Province  
(After Wolfe, 1977)

**APPENDIX I**

**ENGINEERING DATA**

**CRANDON LAKE DAM**

1. Dam Description

This dam will be constructed in a presently completely undeveloped area. The stream channel and flood plain upstream of the dam site are flat, offering an excellent location for a lake.

At the examiner's request, a trench, approximately 4 ft. deep and 6 ft. wide, was dug along the center line of the dam for its full length. Several test holes were also dug into the bottom of this trench. The entire foundation below grade is believed to be a tight, highly impervious gray clay, satisfactory for the formation into which the compacted, central core will penetrate.

In the examiner's opinion, this clay may not be satisfactory for the central core due to the absence of coarse materials, and the probable resultant low plasticity. At his request, therefore, a site for borrow material was located which contained material, which by inspection, appeared to be very satisfactory for the compacted, central core. It contained a yellow clay with sufficient coarse grain material to prevent the core from cracking when dry, or becoming plastic when wet. See inspection report dated June 10, 1957.

Hydrology

Encroachment Applications #910 & 911 (21-37 & 21-38) approved county bridges e.e. for Central Jersey curve run-off.

Lake Mead on an adjacent watershed, April. 105 (21-20) was approved for 75% South Jersey curve run-off.

Quick Pond and Necca Lake are two large ponds a short distance above the proposed lake. The two existing and the proposed new 70-acre lake will, in the opinion of the examiner, suppress major floods to below Central Jersey curve run-off. A conservative design, having a frequency of from 50 to 100 years is therefore estimated as C.J. curve run-off.

Hydraulics of Spillway Trunk for Q = 560 cfs.

Invert at Outlet	El. 855.30
Probable Depth at Outlet	6.00 ft.
Vel. H.d. at outlet	1.52 ft.
Friction loss for n = .021	.55 ft.
Entrance loss, K = 0.5	.76 "
Energy Line & Spillway Pool level El. 855.30	
Spillway Crest	El. 855.30

Spillway Hydraulics

H for the design flood of 560 cfs (no submergence)  $\frac{C}{(1-1.33^{2/3})} = 2.36$  ft.  
 $Q$  for  $H = 1.00$  ft. (dam crush) is as follows, as computed from the formula for correction of weir coefficient due to submergence:-

$$C' = C(1-H^{2/3}).385$$

1. Compute submergences of spillway crest for several critical values of discharge in accordance with the method of the preceding paragraph.
2. Plot submergence vs discharge (See attached curves).
3. For a selected  $H$ , compute the discharges corresponding to several critical submergences, using corrected weir coefficients from above formula.
4. Again plot submergence vs discharge.
5. The intersection of the two plotted lines gives the corrected discharge for the selected  $H$ .

Thus the spillway and spillway trunk have capacity to discharge 823 cfs with the dam crushed. This is approximately equal to mean, h.4 C.J. curve run-off.

Thus the spillway and spillway trunk have capacity to discharge 923 cfs with the dam awake. This is approximately equal to mean, 6.5 C.J. curve run-off.

specifications

The specifications include and adequately cover all necessary provisions for the proper construction of the dam.  
as may be considered necessary, ~~and reserves to the State Water Policy Commission the right to suspend or revoke this permit~~  
~~at any time should such action be deemed advisable in the interest of public safety.~~

(See below) 3. That the work shall be under the direction of a competent engineer, and that he or a ~~representative of the engineer~~ ~~shall remain at the site of construction and until the completion of the work.~~

4. That the Commission shall be notified in advance of the proposed time of the commencement of the work that no material shall be placed on any portion of the foundation until such portion of the foundation has been approved in writing by a representative of the Commission.

5. That a report, on forms to be submitted by the Commission, on the status of the construction work shall be mailed to the State Water Policy Commission, 24 West State Street, Trenton, New Jersey, on the first day of each month until the work upon the dam has been completed.

6. That no brush or waste timber cleared from the area under this approval shall be burned unless and until the party doing the work shall have obtained a permit from the Fire-Warden of the district in which the burning is to be done, in accordance with Title 13:8-19 of the Revised Statutes.

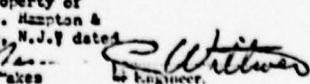
7. That no bushboards or other obstruction shall be placed or permitted to remain on the crest of the spillway.

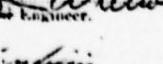
8. That the work shall be started within **one year** from date of this permit and completed within **two years** from said date; otherwise, this permit, if not previously revoked or specifically extended, shall cease and be null and void.

9. This permit shall not become operative unless and until the applicant shall file with the Commission within thirty days from date hereof, upon a form furnished by the Commission, its written acceptance of the terms and conditions hereby imposed.

10. That all work shall be performed under the direct supervision at all times of a competent professional engineer licensed in the state of New Jersey, or his qualified representative. Acceptance of the dam for operation will be subject to a certification by the engineer that the dam has been constructed in conformance with the drawings and specifications submitted and hereby approved, or with modifications of these drawings subsequently approved.

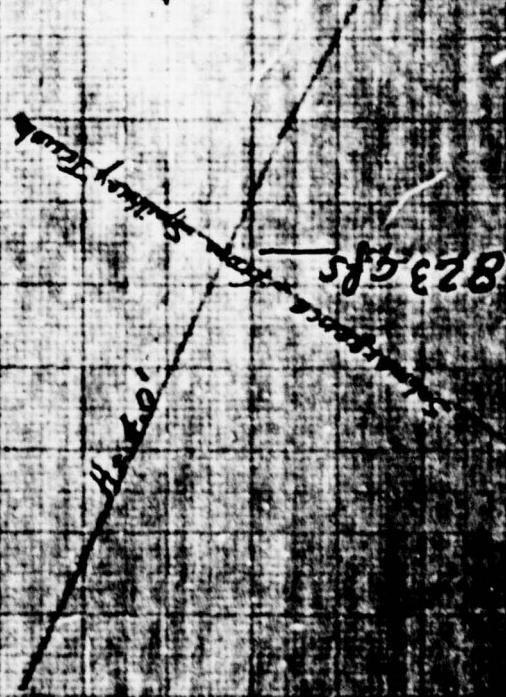
11. The drawings hereby approved are three sheets prepared by Salvo J. Clarke, P.E., entitled as follows:

Sheet 1 - "Map of a Portion of the Property of  
Grandon Lakes Dev. Co., Inc., Hampton &  
Stillwater Twp., Sussex Co., N.J." dated  
March, 1957. 

Sheet 2 - "Grandon Lake Dam, Grandon Lakes  
Dev. Co., Inc., Hampton-Stillwater  
Twp., - Sussex Co.", dated June, 1957. 

Trenton, New Jersey, July 23, 1957. Sheet 3 - "Grandon Lake Dam, Grandon Lakes Dev. Co., Inc., Hampton-Stillwater Twp., - Sussex Co.", dated June, 1957. In Charge Inspector & Director

Discharge For  $H = 4.0'$



**APPENDIX 2**

**CHECK LIST**

**VISUAL INSPECTION**

**CRANDON LAKE DAM**

CHECK LIST  
VISUAL INSPECTION  
Phase I

NAME DAM Crandon Lake Dam COUNTY Sussex STATE New Jersey COORDINATORS N.J.D.E.P.

DATE(s) INSPECTION See below WEATHER Overcast & cold TEMPERATURE 25° F

POOL ELEVATION AT TIME OF INSPECTION 855.2\* M.S.L. TAILWATER AT TIME OF INSPECTION 846\* M.S.L.

\* Elevations based on BM of El. 855.3 (Ref. Fig 2)

INSPECTION PERSONNEL:

J. Richards	<u>12/20/78</u>	<u>12/13/78</u>
P. Yu	<u>12/20/78</u>	<u>12/13/78</u>
C. Campbell	<u>12/13/78</u>	

Peter Yu RECORDER

DOWNSTREAM CHANNEL		REMARKS OR RECOMMENDATIONS
VISUAL EXAMINATION OF	OBSERVATIONS	
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Leaves, wood boards, a few fallen trees partially obstruct downstream channel.	Debris and obstructions should be removed.
SLOPES	Appear satisfactory	
APPROXIMATE NO. OF HOMES AND POPULATION	No homes immediately downstream. Approximately (5) at relatively low elevations around the perimeter of the lower lake about 1000 ft downstream and numerous scattered homes at high elevations. Est. population 30 people, lower lake area about 10 acres, LISGS Topo Map and visual inspection.	

**EMBANKMENT**

<b>VISUAL EXAMINATION OF</b>	<b>OBSERVATIONS</b>	<b>REMARKS OR RECOMMENDATIONS</b>
SURFACE CRACKS	None Observed	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None Observed	
SLoughing or Erosion of Embankment and Abutment Slopes	Trees grow on slopes of embankment. Erosion has occurred along the sides of the downstream headwalls for outlet conduits. Some erosion has occurred on upstream slope near the drop box structure and at a few other locations	Eroded areas should be filled
Vertical and Horizontal Alignment of the Crest	Appear satisfactory	
Riprap Failures	Riprap not uniform along upstream face; no failures observed.	

EMBANKMENT		REMARKS OR RECOMMENDATIONS	
VISUAL EXAMINATION OF	OBSERVATIONS		
OTHER	Six inch diameter by ten inch deep animal hole downstream slope near the 36 in-dia outlet structure.	Hole should be filled.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Appear Satisfactory		
ANY NOTICEABLE SEEPAGE	None Observed		
STAFF GAGE AND RECORDER	None Observed		
DRAINS	None Observed		

**OUTLET WORKS**

<b>VISUAL EXAMINATION OF</b>	<b>OBSERVATIONS</b>	<b>REMARKS OR RECOMMENDATIONS</b>
<b>CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT</b>	Rust on the two 6-ft-dia spillway outlet pipe and the 36-in blow-off pipe near flow line.	Rusted pipes should be replaced or relined.
<b>INTAKE STRUCTURE</b>	Numerous cracks observed on upstream face of concrete headwall of the 6-ft-dia conduit. Three cracks extend to the top and appear on exposed sides of the wall. At left junction of drop box/headwall, water seepage.	Cracks should be further investigated. Leakage at junction should be repaired.
<b>OUTLET STRUCTURE</b>	Approx. 1-in-wide crack on downstream face of headwall for the two 6-ft-dia conduits. Minor spalling on headwall for the 36-in pipe.	Cracked and spalled concrete should be repaired.
<b>OUTLET CHANNEL</b>	Metal drum in outlet channel of the 36-in pipe.	Outlet channel should be cleaned of any debris.
<b>EMERGENCY GATE</b>	None observed	

## RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARK OR RECOMMENDATIONS
SLOPES	Satisfactory condition except some minor erosion in limited area. ( 6 Hor. to 1 Vert. earth slope with occasional vertical bulkhead from some homes.)	
SEDIMENTATION	Appears satisfactory	

## UNGATED SPILL WAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Concrete spalled on left weir outside edge, 8-in x 4-in x 1/2-in. Minor deterioration on inside faces of the drop box spillway.	Concrete should be repaired.
APPROACH CHANNEL	None Observed	
DISCHARGE CHANNEL		Appears satisfactory.
BRIDGE AND PIERS	None observed	

**APPENDIX 3**

**PHOTOGRAPHS**

**CRANDON LAKE DAM**



Upstream face of dam. Looking west.

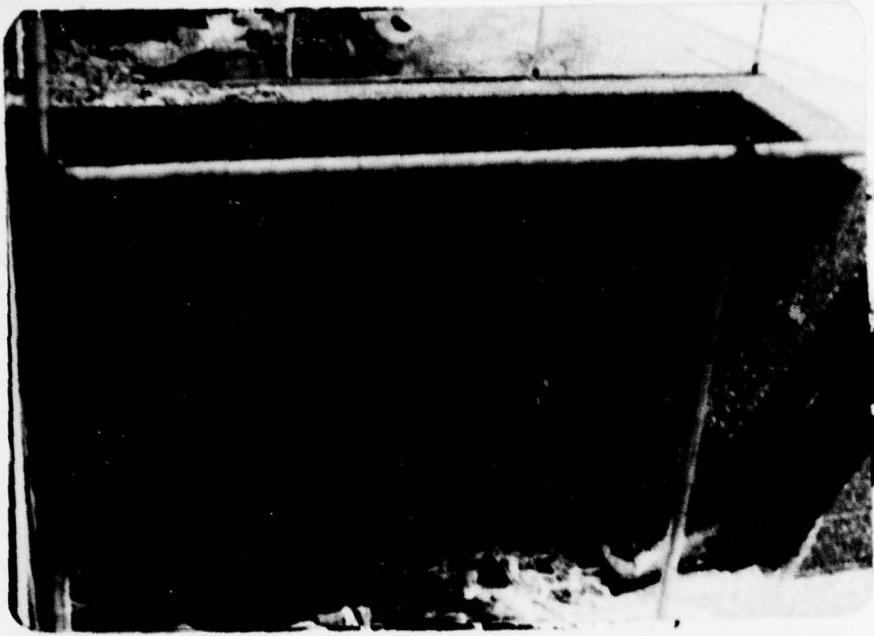
20 December 1978



Upstream face of dam. Looking east.

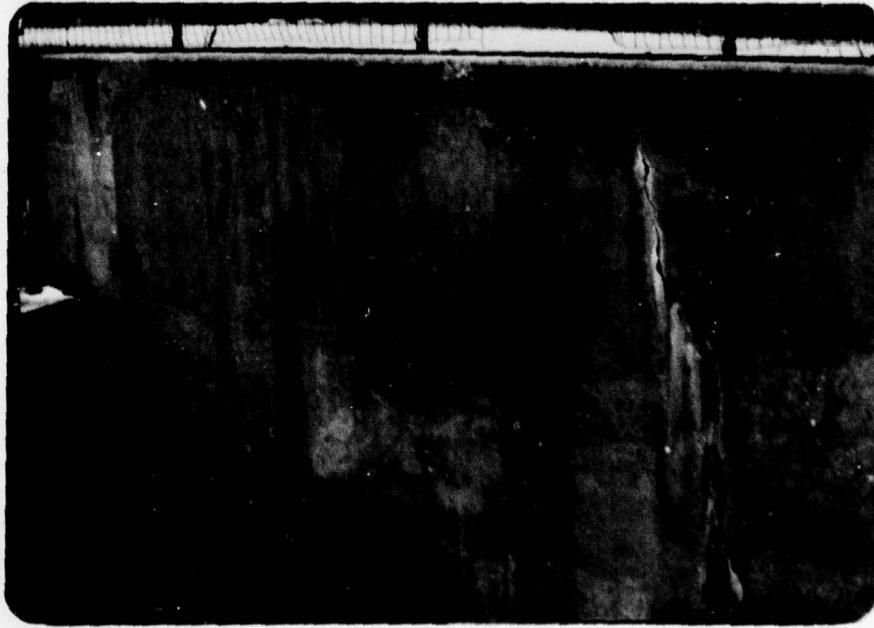
20 December 1978

#### CRANDON LAKE DAM



Concrete drop box spillway.

20 December 1978



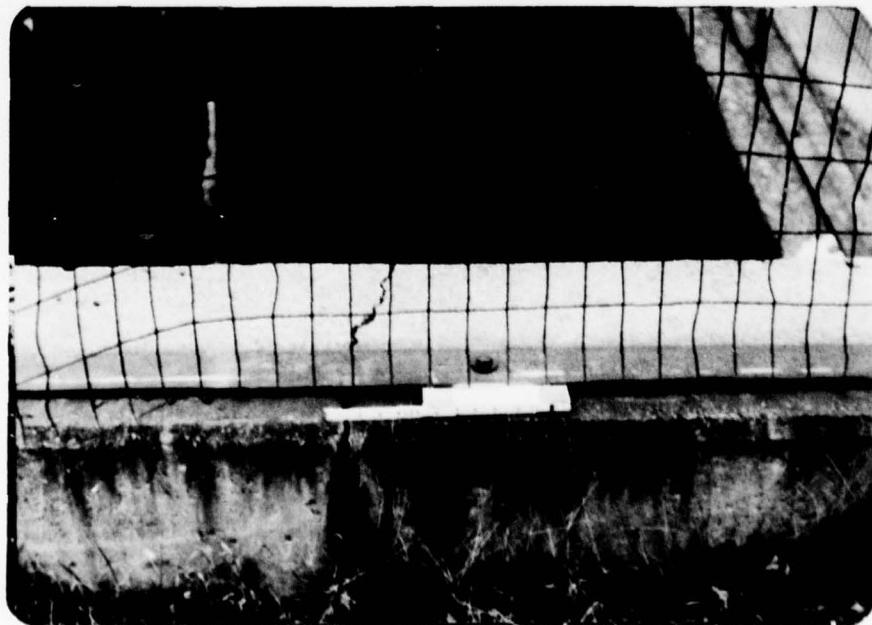
Cracks in headwall of drop box spillway.  
Note frozen seepage in corner of box at  
left of photo.

20 December 1978



Water seeping at joint at left wall of drop box spillway.

20 December 1978



Open crack, 1/2-in at headwall of drop-box spillway.

20 December 1978

CRANDON LAKE DAM



Erosion at left spillway/embankment junction.

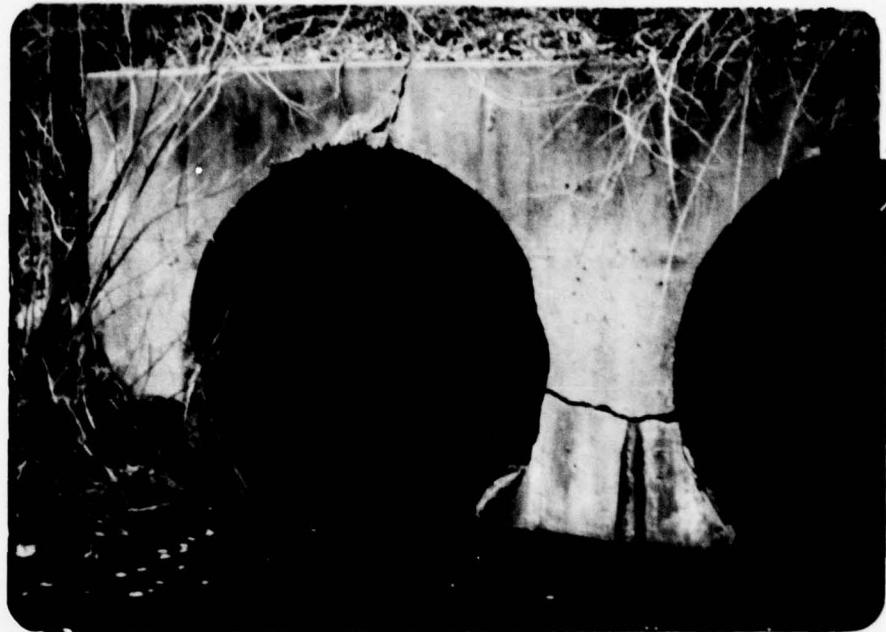
20 December 1978



Erosion at right spillway/embankment junction.

20 December 1978

#### CRANDON LAKE DAM



Spillway outlet conduits. Concrete cracked at top and at spring line.

20 December 1978



Left spillway outlet conduit.

20 December 1978

CRANDON LAKE DAM



Low level outlet conduit.  
Looking upstream.

20 December 1978



Debris, riprap and trees on  
upstream face of dam.

20 December 1978



Discharge channel for drop-box  
spillway. Looking downstream.

20 December 1978



Downstream discharge where channel  
drop-box spillway and low level outlet  
discharge merge.

20 December 1978



Concrete slope protection along  
discharge channel for drop-box  
spillway.

20 December 1978



Crandon Lake.

20 December 1978

**APPENDIX 4**

**HYDROLOGIC COMPUTATIONS**

**CRANDON LAKE DAM**

HYDROLOGIC COMPUTATIONSCRANDON LAKE DAMLocation: Sussex County, N.J.Drainage Area: 2.45 sq.mi.Lake Area: 70 Ac.Classification: Size - Small  
Hazard - highSpillway Design Flood

Based on available information, it is understood that the spillway has been designed on the basis of a design flood of 560 cfs with 2.34 ft head (no submergence). This peak discharge corresponds to a flood having a frequency of 50 years. In accordance with evaluation criteria,  $\frac{1}{2}$  PMF to PMF should be used. PMF is chosen for analysis.

Compute PMF

1. Dam located in Zone 1 (south boundary)

PMP = 22 inches

2. PMF must be adjusted for basin size (since dam locates close to zone 6, ∴ take average)

Duration	% Factor (for 10 sq mi)			Reduction Factor
	Zone 1	Zone 6	Average	
0-6	111	112	112	
0-12	123	123	123	
0-24	133	132	133	
0-48	142	142	142	
				0.80

BY D.P.

DATE 7-17-79

Crandon Lake Dam

JOB NO. J-783 B

CKD/SPD

DATE 4-19-79

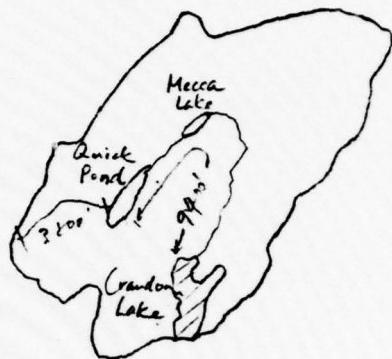
SHEET NO. 1 OF 12

DETERMINE TIME OF CONCENTRATION

1. Majority area of watershed is hilly and wooded
2. Main channel is about 9400' stream (including 2 lakes) & 3800' overland flow
3. Estimated slopes

$$\text{overland} = \frac{560}{3800} = 14.7\%$$

$$\text{stream} = \frac{80}{9400} = 0.85\%$$



4. Estimate  $T_c$  based on average velocity and lengths

	slope	Velocity	remarks
overland flow	14.7%	1.7 fps	wooded valley
stream channel	0.85%	1.85 fps	use gutter flow

$$T_c = \left[ \frac{3800}{1.2} + \frac{9400}{1.85} \right] \div 3600 = 2.29 \text{ hrs.}$$

$$L = 0.6 T_c = 1.4 \text{ hr.}$$

5. Estimate  $T_c$  from state DEP Nomograph

$$\Delta H = 640 \text{ ft}$$

$$L = 13200 \text{ ft}$$

$$T_c = 37 \text{ min.}$$

$$\therefore L = 22 \text{ min.}$$

BY PgDATE 2-20-79 Grandon LakeJOB NO. J-783B

CKD/CED

DATE 4-19-79SHEET NO. 2 OF 12

LANGAN ENGINEERING ASSOCIATES, INC.

6. Estimate  $T_c$  from curve number method  
SCS (Tech Release 55 Fig. 3-3)

$$l = 13200 \text{ ft.}$$

$$\text{Ave slope} = \frac{14.7 \times 3800 + 0.85 \times 9400}{13200} = 4.84\%$$

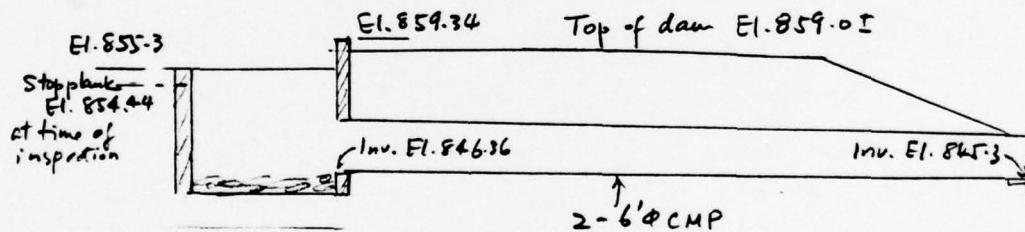
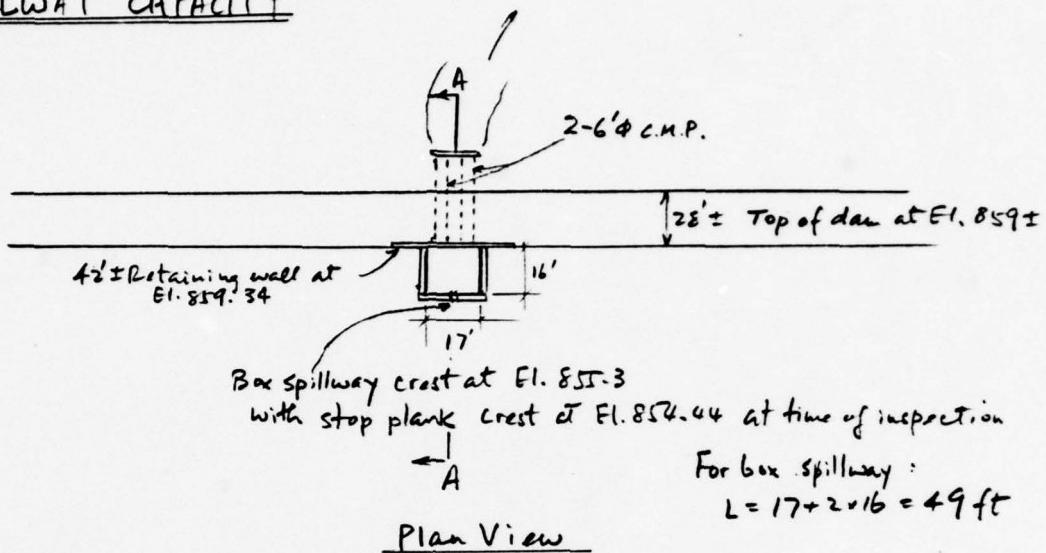
$$CN = 80$$

$$\underline{L = 1.3}$$

Answe L = 1.3 hrs.

BY Dy DATE 2-20-79 Grand Lake Dam  
CKD GED DATE 4-19-79

JOB NO. J-7F3 6  
SHEET NO. 3 OF 12

SPILLWAY CAPACITYSection A-A

At time of inspection, one stop plank (3' long) was removed from the spillway box, and its crest was at El. 854.44. Since existing condition is below its normal flowline (spillway crest), it would be unconservative to analyze existing condition. Therefore, it is assumed that the stop plank is replaced and storm starts when pool level is at spillway crest. As discharge increases, the headwater in the culvert pipes rises; and eventually the culvert filled. Discharge capacity will be governed by the culvert if its capacity ever becomes less than that of the spillway.

Discharge of culvert when just filled (headwater for culvert at 852.36) :

'Open-channel Hydraulics' by Chow, 1959

Fig. 17-30 on pg. 498

$$\frac{H}{d} = 1, d = 72, \text{ then } Q = 2 \times 200 = 400 \text{ cfs (2-6'Ø CMP)}$$

Approximate head above box spillway when culvert entrance filled

$$H = \left( \frac{Q}{C_L} \right)^{\frac{3}{2}} \quad \text{use } C \approx 3.0 \text{ (Table 5-3 of}$$

$$= \left( \frac{400}{3 \times 49} \right)^{\frac{3}{2}} \quad \text{'Handbook of Hydraulics'}$$

by King & Brater)

$$\approx 1.95 \text{ ft}$$

∴ Culvert filled when lake elevation at El. 857.25

For embankment section, assume discharge obeys weir equation when overtop

$$\text{use } C_{avg} = 2.7$$

Section with retaining wall (above culvert entrance) crest at El. 859.34 :

$$L = 42 \text{ ft}$$

Section with embankment crest at El. 859.0

$$L = 428 - 42 = 386 \text{ ft.}$$

BY Pdg

DATE 2-20-79

CKD GED

DATE 4-19-79

JOB NO. J783B

SHEET NO. 5 OF 12

## LANGAN ENGINEERING ASSOCIATES, INC.

Elevation (ft)	Boca Spillway			Culvert (2'-6"dia)			Embankment			Embankment at retaining wall section	Total (ft) $Q_E + Q_{sp}$
	H(ft)	C	$Q_E(\text{cfs})$	H(ft)	$H_A$	$Q_E(\text{cfs})$	H(ft)	$H_A$	$Q_E(\text{cfs})$		
855.3	0	0	0	1.35							135
856.3	1	2.75		4.20	10.94	1.82	7.50				42.0
857.3	2	3.03		8.45	11.94	1.99	8.20				820
858.3	3	3.32			12.64	2.11	8.40				840
859.0	3.7				12.98	2.16	8.50	0	0.34		1057
859.34	4.04				13.98	2.33	9.20	1.34	2.07	0	
860.34	5.04				14.98	2.50	9.90	2.34	1.17	1	113
861.34	6.04				15.98	2.66	10.30	3.34	37.31	2	2650
862.34	7.04				16.98	2.83	10.80	4.34	6362	3	5044
863.34	8.04				17.98	3.00	11.20	5.34	9423	4	7981
864.34	9.04								12861	5	11410
											15249
											1268

BY P.J.  
CKD

DATE 2-20-79

Grandon Lake Dam

DATE 4-19-79

JOB NO. J-7833

SHEET NO. 6 OF 12

$$Q_E = 49 C H^{3/2}$$

$Q_c$  from Fig. 17-30 on Pg. 498 of 'Open-channel Hydraulics' by Chow, 1959

$$Q_E = 1042.2 H^{3/2}$$

$$Q_{sp} = 113.4 H^3$$

LANGAN ENGINEERING ASSOCIATES, INC.

Spillway Rating Curve (Crandon Lake Dam)

10

8

6

4

2

0

Head w/r of Spillway crest (ft)

Top of dam at El. 859.0

Culvert headwater & spillway headwater become even

Spillway box  
being filled

Culvert filled when spillway head  
at this elevation (El. 857.25)

Spillway  
crest at  
El. 855.3

2 4 6 8 10 12 14

Total Discharge Q (1000 cfs)

BY Pj

DATE 2-21-79 Crandon Lake Dam

JOB NO. I-763B

CKD/CED

DATE 4-19-79

SHEET NO. 7

OF 12

Reservoir Storage Capacity

Assume a linear distribution for the area of the lake with elevation. Start at a zero storage at the crest of the spillway.

Area of lake = 70 Ac.

Length of equivalent square = 1746 ft

Take average side slope = 1 V.: 6 H.

∴ for every foot of water above the crest of spillway the length of equivalent square increases by  
 $= 1 \times 6 \times 2 = 12 \text{ ft.}$

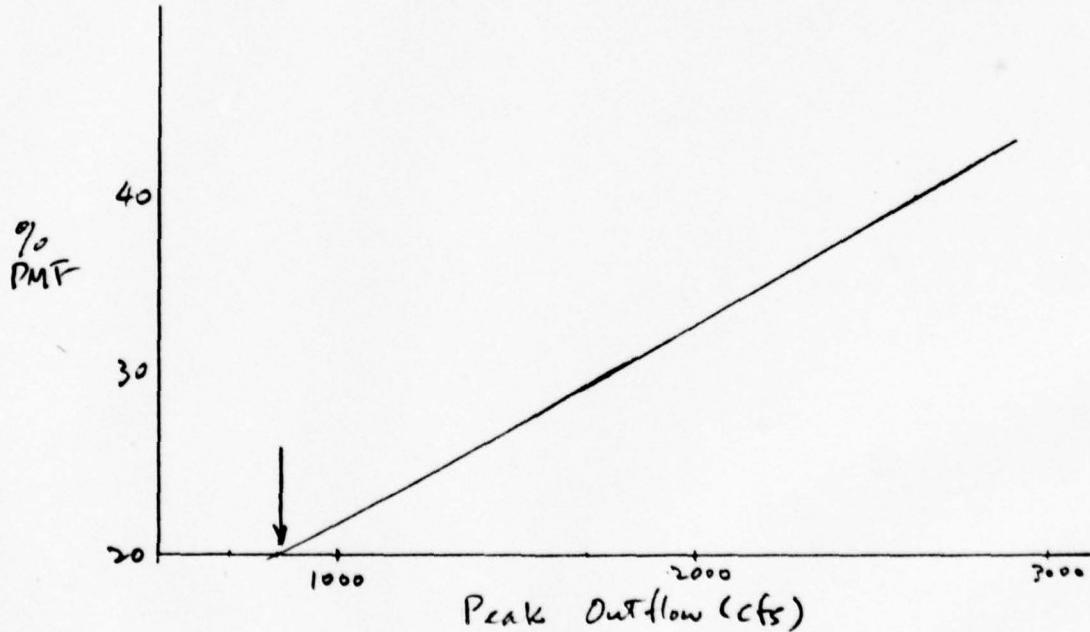
Elev. (ft)	H (ft)	Length of equivalent square (ft)	Area of Lake (Acres)
855.3	0	1746	70
856.3	1	1758	71
857.3	2	1770	72
858.3	3	1782	73
859.3	4	1794	74
860.3	5	1806	75
861.3	6	1818	76
862.3	7	1830	77
863.3	8	1842	78
864.34	9.01	1854	79

SUMMARY OF HYDROGRAPH AND FLOOD ROUTING

1. Hydrograph and routing calculated using HEC-1 DB
2. PMF peak inflow for Crandon Lake is 7807 cfs  
(routed to 7489 cfs)
3. Routing indicates that the dam will overtop  
by approximately 3.2 ft for PMF

OVERTOPPING POTENTIAL

1. Various % of PMF has been routed using HEC-1 DB
2. Plot peak outflow vs % PMF



3. Dam overtops at approx. El. 859 with  $Q = 840$  cfs  
 $\therefore$  dam can pass approx. 20 % of PMF.

BY Pg DATE 2-21-79 Crandon Lake Dam  
CKD/ED DATE 4-19-79

JOB NO. J-783 B  
SHEET NO. 9 OF 12

DRAWDOWN ANALYSIS

## 1. Outlet structures

One 36"-Ø blow off pipe (length = 92' from available data)  
stop-planks in spillway box

For this analysis, assume drawdown is achieved by  
opening the under-water gate for the 36"-Ø pipe only.

## 2. Outlet capacity

From Fig. 17-27 of Chow's book, the pipe can be  
determined as hydraulically long.

∴ pipe flows full. Inv. of outflow of pipe = El. 843.4

$$\text{Discharge of pipe based on } Q = A \sqrt{\frac{2gH}{1+K_m+K_p L}}$$

Take L=92 ft, K<sub>m</sub>=1.0, K<sub>p</sub>=0.0267 (based on n=0.025, Ref. NEH Sect. 5, ES-42)

Use Fig. 6-25 of 'Baltimore County, Storm Water Management Policy'

Elev. (ft)	Head (ft)	Q (cfs)	Qoutage (cts)
855.3	12	93.9	91.9
854.3	11	89.9	87.8
853.3	10	85.7	83.5
852.3	9	81.3	79.0
851.3	8	76.6	74.2
850.3	7	71.7	69.1
849.3	6	66.4	63.5
848.3	5	60.6	57.4
847.3	4	54.2	50.6
846.3	3	46.9	42.6
845.3	2	38.3	

BY Dg

DATE 2-21-79 Cranberry Lake Dam

JOB NO. J-7838

CKD/ED

DATE 4-17-79

SHEET NO. 10 OF 12

## 3. Storage capacity

a. Assume capacity of lake at normal pool (El. 855.3)  
 $\approx 230 \text{ Ac-ft}$

(Preconstruction information indicates  
 lake capacity  $\approx 230 \text{ Ac-ft}$ )

b. Assume area varies linearly with height  
 Area of lake at El. 849.3  $\approx ? \text{ Ac.}$

Elev. (ft)	Area (Ac)	$\Delta$ Storage (Ac-ft)	Total (Ac-ft)
855.3	.70	65	230
854.3	59.5	54	
853.3	49	44	
852.3	38.5	33	
851.3	28	23	
850.3	17.5	12	
849.3	7		

By

DATE 2-21-79 Grandon Lake Dam

JOB NO. J-7E3B

CKD/ED

DATE 4.14.79

SHEET NO. 11 OF 12

LANGAN ENGINEERING ASSOCIATES, INC.

4. Assume inflow to be 2 cfs / sq mi

$$Q_{in} = 2 \times 2.45 = 4.9 \text{ cfs}$$

Elev. (ft)	$Q_{out\ avg.}$ (cfs)	$Q_{net}^*$ (cfs)	$\Delta S_{torage}$ (ac-ft)	$\Delta t(\text{hrs})$	$\sum \Delta t(\text{hrs})$
855.3	91.9	87	65	9.0	
854.3	87.8	82.9	54	7.9	
853.3	83.5	78.6	44	6.8	23.7 (1 day)
852.3	79.0	74.1	33	5.4	
851.3	74.2	69.3	23	4.0	
850.3	69.1	64.2	12	2.3	35.4 (1.5 days)
849.3					

$$* Q_{net} = Q_{out\ avg} - Q_{in} = Q_{out\ avg} - 4.9$$

∴ lake can be lowered 3 ft in about 1 day  
and 6 ft in about 1½ days (from spillway crest)

BY Pjy DATE 2-21-79 Grandine Lake Dam

JOB NO. J 783 B

CKD 7ED DATE 4-17-79

SHEET NO. 12 OF 12





2  
DRAINAGE BASIN  
CRANDON LAKE DAM

MAP SOURCE: U.S.G.S.  
CULVERS GAP, NEWTON WEST  
SCALE: 1" = 2000'

LANGAN ENGINEERING ASSOCIATES, INC.

CONSULTING ENGINEERS  
200 CLIFTON AVE CLIFTON, N.J. 07012 201-577-3365

**HEC-I OUTPUT**

**CRANDON LAKE DAM**

FLUID HYDROGRAPH PACKAGE (HEC-1)  
DATA SAFETY VERIFICATION JULY 1975  
LAST MODIFICATION 11 JAN 75

GRANDU LAKE DAM INFLOW HYDROGRAPH AND ROUTING N.J. DAM INSPECTION						
1	A	A	0	0	0	0
2	R	150	0	20	0	0
3	R1	3				
4	K					
5	K1					
6	K1 COMPUTE HYDROGRAPH	1				
7	R'	1	2	2.45		
8	P	22.0	112	123	133	0.8
9	T				142	1
10	U?	1.3				.15
11	X	-2	1			
12	X	1	2			
13	K1 ROUTING COMPUTATIONS					
14	Y					
15	Y1	1				
16	Y4	655.3	856.3	857.3	858.3	859.0
17	Y4554.54					859.34
18	Y5	0	155	420	820	840
19	Y5	15249				1057
20	Y5	70	71	72	73	74
21	Y5	655.3	856.3	857.3	858.3	859.3
22	SS	855.3				
23	SS	859.0				
24	K	59				

PREDICTION OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT  
ROUTE HYDROGRAPH TO  
END OF NETWORK

1

2

FLUOUD HYDROGRAPH PACKAGE (HEC-1)  
DAM SAFETY VERS. 1.0  
LAST MODIFICATION 11 JAN 79

DATE 1978/21.  
TIME 13.10.37.

CRANDON LAKE DAM  
INFLUX HYDROGRAPH AND ROUTING  
N.J. DAM INSPECTION

JOP SPECIFICATION					
NO	NHR	NMIN	ILAY	IMIN	MIFRC
150	0	20	C	0	0
			JOPER	NWT	LROPT
			3	0	TRACE
				0	0

SUB-AREA RUNOFF COMPUTATION

CUMULF HYDROGRAPH

INORG	TUNG	TAKFA	SHAP	HYDROGRAPH DATA	RATIO	ISNO <sub>0</sub>	ISAME <sub>0</sub>	LOCAL <sub>0</sub>
1	1	0	0	0	0	0	0	0
	2	2.45	0.09	2.45	.80	0.00	0	0

LROPT	STRAK	PLT&K	KATOL	FRAFH	STRAK	CHSTL	ALSMX	PTEMP
	0.00	0.00	1.00	0.00	1.00	.15	0.00	0.00
UNIT HYDROGRAPH DATA								
TC= 0.00 LAGE= 1.50								
STRTG= -2.00	CHCF= 0.00	RECESSI <sub>0</sub> DATA						

STRTG= -2.00 CHCF= 0.00 RTIDP= 1.00

U'11 HYDROGRAPH 21 END OF PERIOD INUTES, TC= 0.00 HOURS, LAG= 1.30 VOL= 1.00  
 100. 2.0. 6.7. 74. 780. 450. 306. 212. 6.  
 102. 71. 4.0. 33. 23. 16. 11. 8.  
 2. 2. 2. 2.

HOUR	MINUTE	PERIOD	RATE	EXCS	LOSS	END-OF-PERIOD FLOW	COMP C			EXCS	LOSS	COMP C
							MOUA	MHMN	PENLON			
1.01	0.20	1	0.00	0.00	0.00	0.00	1.02	1.20	7.6	0.04	0.00	0.04
1.01	0.40	2	0.00	0.00	0.00	0.00	1.02	1.40	7.7	0.04	0.00	0.04
1.01	0.60	3	0.00	0.00	0.00	0.00	1.02	2.00	7.8	0.04	0.00	0.04
1.01	0.80	4	0.00	0.00	0.00	0.00	1.02	2.20	7.9	0.04	0.00	0.04
1.01	1.00	5	0.00	0.00	0.00	0.00	1.02	2.40	8.0	0.04	0.00	0.04
1.01	1.20	6	0.00	0.00	0.00	0.00	1.02	2.60	8.1	0.04	0.00	0.04
1.01	1.40	7	0.00	0.00	0.00	0.00	1.02	2.80	8.2	0.04	0.00	0.04
1.01	1.60	8	0.00	0.00	0.00	0.00	1.02	3.00	8.3	0.04	0.00	0.04
1.01	1.80	9	0.00	0.00	0.00	0.00	1.02	3.40	8.3	0.04	0.00	0.04
1.01	2.00	10	0.00	0.00	0.00	0.00	1.02	4.00	8.4	0.04	0.00	0.04
1.01	2.20	11	0.00	0.00	0.00	0.00	1.02	4.20	8.5	0.04	0.00	0.04
1.01	2.40	12	0.00	0.00	0.00	0.00	1.02	4.40	8.6	0.04	0.00	0.04
1.01	2.60	13	0.00	0.00	0.00	0.00	1.02	5.00	8.7	0.04	0.00	0.04
1.01	2.80	14	0.00	0.00	0.00	0.00	1.02	5.20	8.8	0.04	0.00	0.04
1.01	3.00	15	0.00	0.00	0.00	0.00	1.02	5.40	8.9	0.04	0.00	0.04
1.01	3.20	16	0.00	0.00	0.00	0.00	1.02	6.00	9.0	0.04	0.00	0.04
1.01	3.40	17	0.00	0.00	0.00	0.00	1.02	6.20	9.1	0.04	0.00	0.04
1.01	3.60	18	0.00	0.00	0.00	0.00	1.02	6.40	9.2	0.04	0.00	0.04
1.01	3.80	19	0.00	0.00	0.00	0.00	1.02	7.00	9.3	0.04	0.00	0.04
1.01	4.00	20	0.01	0.00	0.01	0.01	1.02	7.20	9.4	0.11	0.06	0.05
1.01	4.20	21	0.01	0.00	0.01	0.01	1.02	7.40	9.5	0.11	0.06	0.05
1.01	4.40	22	0.01	0.00	0.01	0.01	1.02	8.00	9.6	0.11	0.06	0.05
1.01	4.60	23	0.01	0.00	0.01	0.01	1.02	8.20	9.7	0.11	0.06	0.05
1.01	4.80	24	0.01	0.00	0.01	0.01	1.02	8.40	9.8	0.11	0.06	0.05
1.01	5.00	25	0.01	0.00	0.01	0.01	1.02	9.00	9.9	0.11	0.06	0.05
1.01	5.20	26	0.01	0.00	0.01	0.01	1.02	9.20	10.0	0.11	0.06	0.05
1.01	5.40	27	0.01	0.00	0.01	0.01	1.02	9.40	10.1	0.11	0.06	0.05
1.01	5.60	28	0.01	0.00	0.01	0.01	1.02	10.00	10.2	0.11	0.06	0.05
1.01	5.80	29	0.01	0.00	0.01	0.01	1.02	10.20	10.3	0.11	0.06	0.05
1.01	6.00	30	0.01	0.00	0.01	0.01	1.02	10.40	10.4	0.11	0.06	0.05
1.01	6.20	31	0.01	0.00	0.01	0.01	1.02	11.00	10.5	0.11	0.06	0.05
1.01	6.40	32	0.01	0.00	0.01	0.01	1.02	11.20	10.6	0.11	0.06	0.05
1.01	6.60	33	0.01	0.00	0.01	0.01	1.02	11.40	10.7	0.11	0.06	0.05
1.01	6.80	34	0.01	0.00	0.01	0.01	1.02	12.00	10.8	0.11	0.06	0.05
1.01	7.00	35	0.01	0.00	0.01	0.01	1.02	12.20	10.9	0.11	0.06	0.05
1.01	7.20	36	0.01	0.00	0.01	0.01	1.02	12.40	11.0	0.11	0.06	0.05
1.01	7.40	37	0.01	0.00	0.01	0.01	1.02	13.00	11.1	0.11	0.06	0.05
1.01	7.60	38	0.01	0.00	0.01	0.01	1.02	13.20	11.2	0.11	0.06	0.05
1.01	7.80	39	0.01	0.00	0.01	0.01	1.02	13.40	11.3	0.11	0.06	0.05
1.01	8.00	40	0.01	0.00	0.01	0.01	1.02	14.00	11.4	0.11	0.06	0.05
1.01	8.20	41	0.01	0.00	0.01	0.01	1.02	14.20	11.5	0.11	0.06	0.05
1.01	8.40	42	0.01	0.00	0.01	0.01	1.02	14.40	11.6	0.11	0.06	0.05
1.01	8.60	43	0.01	0.00	0.01	0.01	1.02	15.00	11.7	0.11	0.06	0.05
1.01	8.80	44	0.01	0.00	0.01	0.01	1.02	15.20	11.8	0.11	0.06	0.05
1.01	9.00	45	0.01	0.00	0.01	0.01	1.02	15.40	11.9	0.11	0.06	0.05
1.01	9.20	46	0.01	0.00	0.01	0.01	1.02	15.60	12.0	0.11	0.06	0.05
1.01	9.40	47	0.01	0.00	0.01	0.01	1.02	15.80	12.1	0.11	0.06	0.05
1.01	9.60	48	0.01	0.00	0.01	0.01	1.02	16.00	12.2	0.11	0.06	0.05
1.01	9.80	49	0.01	0.00	0.01	0.01	1.02	16.20	12.3	0.11	0.06	0.05
1.01	10.00	50	0.01	0.00	0.01	0.01	1.02	16.40	12.4	0.11	0.06	0.05
1.01	10.20	51	0.01	0.00	0.01	0.01	1.02	16.60	12.5	0.11	0.06	0.05
1.01	10.40	52	0.01	0.00	0.01	0.01	1.02	16.80	12.6	0.11	0.06	0.05
1.01	10.60	53	0.01	0.00	0.01	0.01	1.02	17.00	12.7	0.11	0.06	0.05
1.01	10.80	54	0.01	0.00	0.01	0.01	1.02	17.20	12.8	0.11	0.06	0.05
1.01	11.00	55	0.01	0.00	0.01	0.01	1.02	17.40	12.9	0.11	0.06	0.05
1.01	11.20	56	0.01	0.00	0.01	0.01	1.02	17.60	13.0	0.11	0.06	0.05
1.01	11.40	57	0.01	0.00	0.01	0.01	1.02	17.80	13.1	0.11	0.06	0.05
1.01	11.60	58	0.01	0.00	0.01	0.01	1.02	18.00	13.2	0.11	0.06	0.05
1.01	11.80	59	0.01	0.00	0.01	0.01	1.02	18.20	13.3	0.11	0.06	0.05
1.01	12.00	60	0.01	0.00	0.01	0.01	1.02	18.40	13.4	0.11	0.06	0.05
1.01	12.20	61	0.01	0.00	0.01	0.01	1.02	18.60	13.5	0.11	0.06	0.05
1.01	12.40	62	0.01	0.00	0.01	0.01	1.02	18.80	13.6	0.11	0.06	0.05
1.01	12.60	63	0.01	0.00	0.01	0.01	1.02	19.00	13.7	0.11	0.06	0.05
1.01	12.80	64	0.01	0.00	0.01	0.01	1.02	19.20	13.8	0.11	0.06	0.05
1.01	13.00	65	0.01	0.00	0.01	0.01	1.02	19.40	13.9	0.11	0.06	0.05
1.01	13.20	66	0.01	0.00	0.01	0.01	1.02	19.60	14.0	0.11	0.06	0.05
1.01	13.40	67	0.01	0.00	0.01	0.01	1.02	19.80	14.1	0.11	0.06	0.05
1.01	13.60	68	0.01	0.00	0.01	0.01	1.02	20.00	14.2	0.11	0.06	0.05
1.01	13.80	69	0.01	0.00	0.01	0.01	1.02	20.20	14.3	0.11	0.06	0.05
1.01	14.00	70	0.01	0.00	0.01	0.01	1.02	20.40	14.4	0.11	0.06	0.05
1.01	14.20	71	0.01	0.00	0.01	0.01	1.02	20.60	14.5	0.11	0.06	0.05
1.01	14.40	72	0.01	0.00	0.01	0.01	1.02	20.80	14.6	0.11	0.06	0.05
1.01	14.60	73	0.01	0.00	0.01	0.01	1.02	21.00	14.7	0.11	0.06	0.05
1.01	14.80	74	0.01	0.00	0.01	0.01	1.02	21.20	14.8	0.11	0.06	0.05
1.01	15.00	75	0.01	0.00	0.01	0.01	1.02	21.40	14.9	0.11	0.06	0.05
1.01	15.20	76	0.01	0.00	0.01	0.01	1.02	21.60	15.0	0.11	0.06	0.05
1.01	15.40	77	0.01	0.00	0.01	0.01	1.02	21.80	15.1	0.11	0.06	0.05
1.01	15.60	78	0.01	0.00	0.01	0.01	1.02	22.00	15.2	0.11	0.06	0.05
1.01	15.80	79	0.01	0.00	0.01	0.01	1.02	22.20	15.3	0.11	0.06	0.05
1.01	16.00	80	0.01	0.00	0.01	0.01	1.02	22.40	15.4	0.11	0.06	0.05
1.01	16.20	81	0.01	0.00	0.01	0.01	1.02	22.60	15.5	0.11	0.06	0.05
1.01	16.40	82	0.01	0.00	0.01	0.01	1.02	22.80	15.6	0.11	0.06	0.05
1.01	16.60	83	0.01	0.00	0.01	0.01	1.02	23.00	15.7	0.11	0.06	0.05
1.01	16.80	84	0.01	0.00	0.01	0.01	1.02	23.20	15.8	0.11	0.06	0.05
1.01	17.00	85	0.01	0.00	0.01	0.01	1.02	23.40	15.9	0.11	0.06	0.05
1.01	17.20	86	0.01	0.00	0.01	0.01	1.02	23.60	16.0	0.11	0.06	0.05
1.01	17.40	87	0.01	0.00	0.01	0.01	1.02	23.80	16.1	0.11	0.06	0.05
1.01	17.60	88	0.01	0.00	0.01	0.01	1.02	24.00	16.2	0.11	0.06	0.

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL	VOLUME
CFS	7607.	4555.	1522.	642.			36236.
CFS	221.	129.	37.	18.			2725.
INCHES		17.29	20.07	20.30			20.30
MM		439.24	539.61	515.62			515.62
AC-FI		2258.	2621.	2651.			2651.
THOUS CUM		2786.	3270.				3270.
SUM		24.99	20.15	4.84	96254.		2725.61)

## ROUTING CONFIGURATIONS

	I STAG 2	I CONP 1	I FCON 0	I TAPE 0	JPLT 0	JPKT 0	I NAME 1	I STAGE 0	I AUTO 0
ALOSS	CLOSS 0.0	Avg 0.00	ROUTING DATA						LSTR 0
NSTPS	NSTOL 1	LAG 0	AMESKK 0.000	X	TSK 0.000		STORA 0.	ISPRAT -1	
SLAQT	655.30 654.34	657.30	H58.30	859.00	859.34	860.34	861.34	862.34	H62.34
FLOU	0.00	135.00	420.00	840.00	1057.00	2650.00	5044.00	7941.00	11410.00
SURFACE AREA =	70.	71.	72.	73.	74.	75.	76.	77.	78.
CAPACITY =	0.	70.	142.	214.	286.	362.	438.	514.	592.
ELEVATION =	655.	656.	657.	658.	659.	660.	661.	662.	664.
CREL	SPWID 955.3	CQW 0.0	EXPW 0.0	ELEV 0.0	COAL 0.0	CARE 0.0	FXPL 0.0		
				LAM DATA					
				TOPEL 859.0	COUD 0.0	FXPD 0.0	DAMWID 0.		
				FIND-OF-PERIOD HYDROGRAPH ORDINATES					
				PERIOD HOURS	INFLOW	OUTFLOW	STORAGE		
MILUA	MILUA								STAGE
1.01	•20	1	•73	5•	0•	0•	0•	0•	855.3
1.01	•40	2	•67	5•	0•	0•	0•	0•	855.3
1.01	1.00	3	1.00	5•	1•	0•	0•	0•	855.3
1.01	1.20	4	1.33	5•	1•	0•	0•	0•	855.3
1.01	1.40	5	1.67	5•	1•	1•	1•	1•	855.3
1.01	2.00	6	2.10	5•	1•	1•	1•	1•	855.3
1.01	2.20	7	2.23	5•	2•	1•	1•	1•	855.3
1.01	2.40	8	2.67	5•	2•	1•	1•	1•	855.3
1.01	3.00	9	3.00	5•	2•	1•	1•	1•	855.3
1.01	3.20	10	3.23	5•	2•	1•	1•	1•	855.3
1.01	3.40	11	3.67	5•	2•	1•	1•	1•	855.3
1.01	4.00	12	4.00	5•	2•	1•	1•	1•	855.3
1.01	4.20	13	4.23	5•	2•	1•	1•	1•	855.3
1.01	4.40	14	4.47	5•					855.3

1.01	5.00	15	5.00	16	5.33	16	5.00	17	5.67	17	5.67	18	6.00	18	6.00	19	6.33	19	6.33	20	6.67	20	6.67	21	7.00	21	7.00	22	7.33	22	7.33	23	7.67	23	7.67	24	8.00	24	8.00	25	8.33	25	8.33	26	8.67	26	8.67	27	9.00	27	9.00	28	9.33	28	9.33	29	9.67	29	9.67	30	10.00	30	10.00	31	10.33	31	10.33	32	10.67	32	10.67	33	11.00	33	11.00	34	11.33	34	11.33	35	11.67	35	11.67	36	12.00	36	12.00	37	12.33	37	12.33	38	12.67	38	12.67	39	13.00	39	13.00	40	13.33	40	13.33	41	13.67	41	13.67	42	14.00	42	14.00	43	14.33	43	14.33	44	14.67	44	14.67	45	15.00	45	15.00	46	15.33	46	15.33	47	15.67	47	15.67	48	16.00	48	16.00	49	16.33	49	16.33	50	16.67	50	16.67	51	17.00	51	17.00	52	17.33	52	17.33	53	17.67	53	17.67	54	18.00	54	18.00	55	18.33	55	18.33	56	18.67	56	18.67	57	19.00	57	19.00	58	19.33	58	19.33	59	19.67	59	19.67	60	20.00	60	20.00	61	20.33	61	20.33	62	20.67	62	20.67	63	21.00	63	21.00	64	21.33	64	21.33	65	21.67	65	21.67	66	22.00	66	22.00	67	22.33	67	22.33	68	22.67	68	22.67	69	23.00	69	23.00	70	23.33	70	23.33	71	23.67	71	23.67	72	24.00	72	24.00	73	24.33	73	24.33	74	24.67	74	24.67	75	25.00	75	25.00	76	25.33	76	25.33	77	25.67	77	25.67	78	26.00	78	26.00	79	26.33	79	26.33	80	26.67	80	26.67	81	27.00	81	27.00	82	27.33	82	27.33	83	27.67	83	27.67	84	28.00	84	28.00	85	28.33	85	28.33	86	28.67	86	28.67	87	29.00	87	29.00	88	29.33	88	29.33	89	29.67	89	29.67	90	30.00	90	30.00	91	30.33	91	30.33	92	30.67	92	30.67	93	31.00	93	31.00	94	31.33	94	31.33	95	31.67	95	31.67	96	32.00	96	32.00	97	32.33	97	32.33	98	32.67	98	32.67	99	33.00	99	33.00	100	33.33	100	33.33	101	33.67	101	33.67	102	34.00	102	34.00	103	34.33	103	34.33	104	34.67	104	34.67	105	35.00	105	35.00	106	35.33	106	35.33	107	35.67	107	35.67	108	36.00	108	36.00	109	36.33	109	36.33	110	36.67	110	36.67	111	37.00	111	37.00	112	37.33	112	37.33	113	37.67	113	37.67	114	38.00	114	38.00	115	38.33	115	38.33	116	38.67	116	38.67	117	39.00	117	39.00	118	39.33	118	39.33	119	39.67	119	39.67	120	40.00	120	40.00	121	40.33	121	40.33	122	40.67	122	40.67	123	41.00	123	41.00	124	41.33	124	41.33	125	41.67	125	41.67	126	42.00	126	42.00	127	42.33	127	42.33	128	42.67	128	42.67	129	43.00	129	43.00	130	43.33	130	43.33	131	43.67	131	43.67	132	44.00	132	44.00	133	44.33	133	44.33	134	44.67	134	44.67	135	45.00	135	45.00	136	45.33	136	45.33	137	45.67	137	45.67	138	46.00	138	46.00	139	46.33	139	46.33	140	46.67	140	46.67	141	47.00	141	47.00	142	47.33	142	47.33	143	47.67	143	47.67	144	48.00	144	48.00	145	48.33	145	48.33	146	48.67	146	48.67	147	49.00	147	49.00	148	49.33	148	49.33	149	49.67	149	49.67	150	50.00	150	50.00	151	50.33	151	50.33	152	50.67	152	50.67	153	51.00	153	51.00	154	51.33	154	51.33	155	51.67	155	51.67	156	52.00	156	52.00	157	52.33	157	52.33	158	52.67	158	52.67	159	53.00	159	53.00	160	53.33	160	53.33	161	53.67	161	53.67	162	54.00	162	54.00	163	54.33	163	54.33	164	54.67	164	54.67	165	55.00	165	55.00	166	55.33	166	55.33	167	55.67	167	55.67	168	56.00	168	56.00	169	56.33	169	56.33	170	56.67	170	56.67	171	57.00	171	57.00	172	57.33	172	57.33	173	57.67	173	57.67	174	58.00	174	58.00	175	58.33	175	58.33	176	58.67	176	58.67	177	59.00	177	59.00	178	59.33	178	59.33	179	59.67	179	59.67	180	60.00	180	60.00	181	60.33	181	60.33	182	60.67	182	60.67	183	61.00	183	61.00	184	61.33	184	61.33	185	61.67	185	61.67	186	62.00	186	62.00	187	62.33	187	62.33	188	62.67	188	62.67	189	63.00	189	63.00	190	63.33	190	63.33	191	63.67	191	63.67	192	64.00	192	64.00	193	64.33	193	64.33	194	64.67	194	64.67	195	65.00	195	65.00	196	65.33	196	65.33	197	65.67	197	65.67	198	66.00	198	66.00	199	66.33	199	66.33	200	66.67	200	66.67	201	67.00	201	67.00	202	67.33	202	67.33	203	67.67	203	67.67	204	68.00	204	68.00	205	68.33	205	68.33	206	68.67	206	68.67	207	69.00	207	69.00	208	69.33	208	69.33	209	69.67	209	69.67	210	70.00	210	70.00	211	70.33	211	70.33	212	70.67	212	70.67	213	71.00	213	71.00	214	71.33	214	71.33	215	71.67	215	71.67	216	72.00	216	72.00	217	72.33	217	72.33	218	72.67	218	72.67	219	73.00	219	73.00	220	73.33	220	73.33	221	73.67	221	73.67	222	74.00	222	74.00	223	74.33	223	74.33	224	74.67	224	74.67	225	75.00	225	75.00	226	75.33	226	75.33	227	75.67	227	75.67	228	76.00	228	76.00	229	76.33	229	76.33	230	76.67	230	76.67	231	77.00	231	77.00	232	77.33	232	77.33	233	77.67	233	77.67	234	78.00	234	78.00	235	78.33	235	78.33	236	78.67	236	78.67	237	79.00	237	79.00	238	79.33	238	79.33	239	79.67	239	79.67	240	80.00	240	80.00	241	80.33	241	80.33	242	80.67	242	80.67	243	81.00	243	81.00	244	81.33	244	81.33	245	81.67	245	81.67	246	82.00	246	82.00	247	82.33	247	82.33	248	82.67	248	82.67	249	83.00	249	83.00	250	83.33	250	83.33	251	83.67	251	83.67	252	84.00	252	84.00	253	84.33	253	84.33	254	84.67	254	84.67	255	85.00	255	85.00	256	85.33	256	85.33	257	85.67	257	85.67	258	86.00	258	86.00	259	86.33	259	86.33	260	86.67	260	86.67	261	87.00	261	87.00	262	87.33	262	87.33	263	87.67	263	87.67	264	88.00	264	88.00	265	88.33	265	88.33	266	88.67	266	88.67	267	89.00	267	89.00	268	89.33	268	89.33	269	89.67	269	89.67	270	90.00	270	90.00	271	90.33	271	90.33	272	90.67	272	90.67	273	91.00	273	91.00	274	91.33	274	91.33	275	91.67	275	91.67	276	92.00	276	92.00	277	92.33	277	92.33	278	92.67	278	92.67	279	93.00	279	93.00	280	93.33	280	93.33	281	93.67	281	93.67	282	94.00	282	94.00	283	94.33	283	94.33	284	94.67	284	94.67	285	95.00	285	95.00	286	95.33	286	95.33	287	95.67	287	95.67	288	96.00	288	96.00	289	96.33	289	96.33	290	96.67	290	96.67	291	97.00	291	97.00	292	97.33	292	97.33	293	97.67	293	97.67	294	98.00	294	98.00	295	98.33	295	98.33	296	98.67	296	98.67	297	99.00	297	99.00	298	99.33	298	99.33	299	99.67	299	99.67	300	100.00	300	100.00	301	100.33	301	100.33	302	100.67	302	100.67	303	101.00	303	101.00	304	101.33	304	101.33	305	101.67	305	101.67	306	102.00	306	102.00	307	102.33	307	102.33	308	102.67	308	102.67	309	103.00	309	103.00	310	103.33	310	103.33	311	103.67	311	103.67	312	104.00	312	104.00	313	104.33	313	104.33	314	104.67	314	104.67	315	105.00	315	105.00	316	105.33	316	105.33	317	105.67	317	105.67	318	106.00	318	106.00	319	106.33	319	106.33	320	106.67	320	106.67	321	107.00	321	107.00	322	107.33	322	107.33	323	107.67	323	107.67	324	108.00	324	108.00	325	108.33	325	108.33	326	108.67	326	108.67	327	109.00	327	109.00	328	109.33	328	109.33	329	109.67	329	109.67	330	110.00	330	110.00	331	110.33	331	110.33	332	110.67	332	110.67	333	111.00	333	111.00	

1.01	22.00	66	6.	23.	12.	855.5
1.01	22.25	67	5.	22.	12.	855.5
1.01	22.40	68	22.07	5.	22.	855.5
1.01	22.00	69	23.00	5.	21.	855.5
1.01	23.20	70	23.33	5.	20.	855.4
1.01	23.40	71	23.67	5.	19.	855.4
1.02	22.00	72	24.00	5.	18.	855.4
1.02	22.20	73	24.33	5.	18.	855.4
1.02	22.40	74	24.67	5.	17.	855.4
1.02	22.00	75	25.00	5.	16.	855.4
1.02	21.20	76	25.33	5.	16.	855.4
1.02	21.40	77	25.67	5.	15.	855.4
1.02	22.00	78	26.00	5.	15.	855.4
1.02	22.20	79	26.33	5.	14.	855.4
1.02	22.40	80	26.67	5.	14.	855.4
1.02	22.00	81	27.00	5.	13.	855.4
1.02	22.20	82	27.33	5.	13.	855.4
1.02	22.40	83	27.67	5.	12.	855.4
1.02	22.00	84	28.00	5.	12.	855.4
1.02	22.20	85	28.33	5.	12.	855.4
1.02	22.40	86	28.67	5.	11.	855.4
1.02	22.00	87	29.00	5.	11.	855.4
1.02	22.20	88	29.33	5.	11.	855.4
1.02	22.40	89	29.67	5.	10.	855.4
1.02	22.00	90	30.00	5.	10.	855.4
1.02	22.20	91	30.33	5.	10.	855.4
1.02	22.40	92	30.67	5.	10.	855.4
1.02	22.00	93	31.00	6.	12.	855.4
1.02	22.20	94	31.33	6.	12.	855.4
1.02	22.40	95	31.67	6.	12.	855.4
1.02	22.00	96	32.00	5.	11.	855.5
1.02	22.20	97	32.33	5.	11.	855.5
1.02	22.40	98	32.67	5.	11.	855.5
1.02	22.00	99	33.00	5.	11.	855.5
1.02	22.20	100	33.33	5.	11.	855.5
1.02	22.40	101	33.67	5.	11.	855.5
1.02	22.00	102	34.00	5.	11.	855.5
1.02	22.20	103	34.33	5.	11.	855.5
1.02	22.40	104	34.67	5.	11.	855.5
1.02	22.00	105	35.00	5.	11.	855.5
1.02	22.20	106	35.33	5.	11.	855.5
1.02	22.40	107	35.67	5.	11.	855.5
1.02	22.00	108	36.00	5.	11.	855.5
1.02	22.20	109	36.33	5.	11.	855.5
1.02	22.40	110	36.67	5.	11.	855.5
1.02	22.00	111	37.00	5.	11.	855.5
1.02	22.20	112	37.33	5.	11.	855.5
1.02	22.40	113	37.67	5.	11.	855.5
1.02	22.00	114	38.00	5.	11.	855.5
1.02	22.20	115	38.33	5.	11.	855.5
1.02	22.40	116	38.67	5.	11.	855.5

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1.1.4.2	15.00	39.00	326.3.	1916.	859.9
1.1.4.2	15.52	39.53	363.7.	2613.	860.7
1.1.4.2	15.46	39.67	4424.	3465.	861.1
1.1.4.2	15.02	40.00	5681.	4429.	861.1
1.1.4.2	15.00	40.00	6105.	6823.	861.9
1.1.4.2	16.20	42.21	7128.	570.	861.6
1.1.4.2	16.40	40.67	7867.	6926.	862.0
1.1.4.2	17.03	41.00	7677.	7499.	862.5
1.1.4.2	17.20	41.33	7028.	7395.	862.1
1.1.4.2	17.40	41.67	6105.	4877.	861.9
1.1.4.2	18.00	42.00	5300.	608.	861.7
1.1.4.2	18.20	42.33	4656.	5306.	861.4
1.1.4.2	18.40	42.67	4004.	4682.	861.0
1.1.4.2	19.00	43.00	3242.	4039.	860.9
1.1.4.2	19.20	43.33	2474.	3322.	860.6
1.1.4.2	19.40	43.67	1758.	2121.	860.3
1.1.4.2	20.00	43.00	1256.	1641.	860.0
1.1.4.2	20.20	43.33	44.00	874.	859.7
1.1.4.2	20.40	43.67	44.67	619.	859.5
1.1.4.2	21.00	43.33	45.00	442.	859.2
1.1.4.2	21.20	43.00	45.33	318.	859.0
1.1.4.2	21.40	43.33	45.67	233.	858.8
1.1.4.2	22.00	43.67	46.00	172.	858.6
1.1.4.2	22.20	43.33	46.33	128.	858.3
1.1.4.2	22.40	44.00	46.67	621.	858.1
1.1.4.2	23.00	44.33	46.00	96.	858.1
1.1.4.2	23.20	44.67	47.00	79.	857.8
1.1.4.2	23.40	47.33	47.33	67.	857.6
1.1.4.2	24.00	47.00	47.67	59.	857.5
1.1.4.2	0.00	44.00	48.00	53.	857.3
1.1.4.2	1.03	44.33	48.33	49.	857.2
1.1.4.2	1.03	44.67	48.67	44.	857.1
1.1.4.2	1.00	44.00	49.00	37.	856.9
1.1.4.2	1.03	44.33	49.33	30.	856.8
1.1.4.2	1.03	44.67	49.67	23.	856.7
1.1.4.2	2.00	44.00	49.00	17.	856.7

PEAK OUTFLOW IS	7485.	AT TIRF	41.00 HOURS
PEAK	1489.		
	212.		
CFS			
CMS			
INCHES			
MM			
AC-FT			
THOUS CUB FT			

24-HOUR	72-HOUR	TOTAL VOLUME
4315.	1277.	92758.
122.	36.	2627.
115.38	19.39	19.57
116.41	492.63	496.98
2149.	2533.	2555.
22639.	3124.	3152.

RUNOFF SUMMARY. AVERAGE FLOW IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)  
AREA IN SQUARE MILES(SQUARE KILOMETERS)

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	1	7807.	4555.	1322.	642.	2.45
KNOTTED TO	( 221.08)( 128.97)( 37.42)( 18.17)( 6.35)					
	2	7469.	4315.	1277.	618.	2.45
	( 212.07)( 122.18)( 36.16)( 17.51)( 6.35)					

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....	ELEVATION	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM	TIME OF FAILURE HOURS
	STORAGE OUTFLOW	855.30	855.30	859.00	266.
		0.	0.	0.	840.
		0.	0.		
RATIO OF RESERVOIR P.M.F. TO S.E.E.L.V	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP	MAX OUTFLOW HOURS
0.00	HB2.17	3.17	505.	7489.	7.00
					41.00
					0.00

\*\*\*\*\*  
2-LINE HYDROGRAPH PACKAGE (HEC-1)  
DAM SAFETY VERSION JULY 1976  
LAST MODIFICATION 11 JUN 79  
\*\*\*\*\*

FLUID HYDROGRAPH PACKAGE (HEC-1)  
DATA SAFETY VERSION JULY 1976  
LAST MODIFICATION 11 JAN 76

RUN DATE 19/02/21.  
TIME 13.25.56.

CRANDON LAKE DAM  
X PMF  
N.J. DAM INSPECTION

HO	TICK	NMIN	IUDAY	JOE SPECIFICATION	IPLT	INSTAN
150	6	20	0	HFTPC JOPER NWT 5	0 U LROP 0	4 0 TRACE 0

MULTI-PLAN ANALYSES TO BE PERFORMED  
NPLAN = 1 NRTIO = 6 LRTIO = 1  
RATIO = 1.00 .50 .40 .30 .20 .10

\*\*\*\*\*  
SUB-AREA RUNOFF COMPUTATION

CUMPUTE HYDROGRAPH

IHYD	IUNG	ITARTA	SNAF	HYDROGRAPH DATA	JPLT	JPRT	INAME	IStage	IAUTO
1	2	2.45	0.00	2.45	0	0	0	0	0

IHYD	PHG	RG	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2.00	112.00	123.00	133.00	0.000	0	0	0

\*\*\*\*\*  
INPUT RUNOFF COMPUTATION RATE

LKOPT	STMR	DLTMR	RTOL	ERAIN	STAKS	RTOK	STRIL	CNSTL	ALSMX	RTIMP
6	0.00	1.00	0.00	0.00	1.00	1.00	1.00	.15	0.00	0.00

TC = 0.00 LAG = 1.30  
 RECEDSION DATA  
 SINK= -2.00 GRCSN= 0.00 RYIQR= 1.00  
 PERIOD FLOW CUMF Q MO.DA HR.MN PERIOD RAIN EXCS LOSS COMP Q  
 SUM 24.99 20.15 4.84 96254.  
 ( 635.)( 512.)( 123.)( 2725.61)

\*\*\*\*\* HYDROGRAPH ROUTING \*\*\*\*\*  
 ROUTING COMPUTATIONS  
 STAGE 1C0HP IEC0P ITAPE JPLT I NAME I STAGE I AUTO  
 2 1 0 0 0 0 0 0  
 0.0 CLOSS AVG IRFS ISAME IUPT IPMP LSTR  
 0.000 0.00 0 1 0 0 0 0  
 NSTPS NSTDL LAG AMSKK TSK STORA ISPRAT  
 1 0 0.000 0.000 0.000 0.000 0. -1  
 STAGE 856.30 857.30 858.30 859.00 859.34 860.34 861.34 863.34  
 854.34  
 FLUX 0.00 135.00 420.00 820.00 840.00 1057.00 2650.00 5044.00  
 15249.00  
 SURFACE AREA= 70.  
 CAPACITY= 0.  
 ELEVATION= 856.  
 CRFL SPWID CWD EXITM FLLVL COQL CAREA EXPF DAMWID  
 55.3 0.0 0.0 0.0 0.0 0.0 0.0 0.0

PEAK OUTFLOW IS 7400. AT TIME 41.00 HOURS  
PEAK OUTFLOW IS 3500. AT TIME 41.33 HOURS  
PEAK OUTFLOW IS 2600. AT TIME 41.67 HOURS  
PEAK OUTFLOW IS 1750. AT TIME 41.67 HOURS  
PEAK OUTFLOW IS 632. AT TIME 42.67 HOURS  
PEAK OUTFLOW IS 402. AT TIME 42.67 HOURS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS  
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)  
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS					
				RATIO 1 1.00	RATIO 2 .50	RATIO 3 .40	RATIO 4 .30	RATIO 5 .20	RATIO 6 .10
HYDROGRAPH AT	1	2.45 (t.35)	1 ( 221.08)(	7807. 110.54)(	3904. 88.43)(	3123. 66.32)(	2342. 44.22)(	1561. 44.22)(	781. 22.11)(
MOUNTED TO	2	2.45 (t.35)	1 ( 212.07)(	7489. 101.60)(	3588. 74.31)(	2624. 49.55)(	1750. 23.57)(	832. 11.38)(	402. 11.38)(

## SUMMARY OF DAM SAFETY ANALYSIS

PLAN	ELEVATION STORAGE OUTFLOW	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
		855.30	855.30	659.00
RATIO OF RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS
1.00	862.17	3.17	505.	7489.
*.50	860.73	1.73	395.	3588.
*.40	860.32	1.32	364.	2624.
*.30	859.77	.77	323.	1750.
*.20	858.74	0.00	246.	832.
*.10	857.24	0.00	137.	402.

\*\*\*\*\*  
 -LUUJ HYDROGRAPH PACKAGE (HLG-1)  
 DAM SAFETY VERSION JULY 1978  
 LAST MODIFICATION 11 JAH 79  
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**APPENDIX 5**

**REFERENCES**

**CRANDON LAKE DAM**

APPENDIX 5

REFERENCES

CRANDON LAKE DAM

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3. Eby, C.F., 1976 Soil Survey of Morris County, New Jersey, U.S. Department of Agriculture, Soil Conservation Service, 111 pp.
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10. Letter to Mr. W.J. Clark from N.C. Wittwer, Asst. Chief Engineer, dated 14 May 1957.
11. Inspection Report by N.C. Wittwer, dated 10 June 1957.
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13. Report on Dam Application, dated approx. July 1957.
14. Inspection Report by W.C. Wittwer, dated 18 Sept. 1957.
15. Inspection Report by M.J. Galley, dated 18 Nov. 1957.
16. Letter to Mr. W.J. Clarke from G.R. Shanklin, Chief Engineer and Acting Director, dated 26 Nov. 1957.
17. Inspection Report by R.L. Hardman, dated 19 Dec. 1957.
18. Letter to Crandon Lakes Development Co. from R.L. Hardman, Bureau of Water Control, dated 5 Oct. 1959.